ASSOCIATION CONNECTING
ELECTRONICS INDUSTRIES

IPC-A-610C

Acceptability for Electronic Assemblies

IPC-A-610C
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In keeping with the U.S. Department of Defense acquisition reform principle of relying on performance requirements whenever practicable, and then relying on contractors to meet those requirements, this standard **has not** been ''adopted.'' However, it is recommended as a reference to be used in the establishment and evaluation of design and process requirements. The adoption notice of the IPC-HDBK-001 is reprinted below to better identify the Department's intent to use ANSI/J-STD-001, IPC-HDBK-001, and IPC-A-610 when evaluating electronic manufacturing strategies, processes, and management.

> ''IPC-HDBK-001, ''Handbook and Guide to the Requirements for Soldered Electrical and Electronic Assemblies to Supplement ANSI/J-STD-001B'' was adopted on January 5, 1998, for use by the Department of Defense (DoD). Department of Defense policy is to rely on performance based requirements whenever practicable and to not require standard management approaches or manufacturing processes in solicitations and contracts. By establishing performance requirements and then relying on contractors to meet those requirements we enable innovation and allow contractors to meet our needs at the lowest cost. Nevertheless Defense program managers and contract oversight personnel must have an understanding of the underlying management, engineering, and manufacturing processes at work so they can evaluate and monitor contractor processes. DoD activities may use this handbook and its associated documents when evaluating electronic manufacturing strategies, processes, and management.''

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Standards Should:
- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:
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- Increase time-to-market
- Keep people out
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Acceptability for Electronic Assemblies

Developed by the IPC Task Group (7-31b) of the Product Assurance Subcommittee (7-30) of IPC

Users of this standard are encouraged to participate in the development of future revisions.

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Foreword

If a conflict occurs between the English and translated versions of this document, the English version will take precedence.

1.1 Scope

This standard is a collection of visual quality acceptability requirements for electronic assemblies. It was prepared by the Product Assurance Committee of the IPC.

This document presents acceptance requirements for the manufacture of electrical and electronic assemblies. Historically, electronic assembly standards contained a more comprehensive tutorial addressing principles and techniques. For a more complete understanding of this document's recommendations and requirements, one may use this document in conjunction with IPC-HDBK-001 and J-STD-001.

IPC-A-610 has criteria outside the scope of J-STD-001 defining handling, mechanical and other workmanship requirements. Table 1-1 is a summary of related documents.

1.2 Purpose

The visual standards in this document reflect the requirements of existing IPC and other applicable specifications. In order for the user to apply and use the content of this document, the assembly/product should comply with other existing IPC requirements, such as IPC-SM-782, IPC-2221, IPC-6011 and IPC-A-600. If the assembly does not comply with these or

Table 1-1 Summary of Related Documents

Document Purpose	Spec.#	Definition
Design Standard	IPC-2220 (Series) IPC-SM-782 IPC-CM-770	Design requirements reflecting three levels of complexity (Levels A, B, and C) indicating finer geometries, greater densities, more process steps to produce the product. Component and Assembly Process Guidelines to assist in the design of the bare board and the assembly where the bare board processes concentrate on land patterns for surface mount and the assembly concentrates on surface mount and through-hole principles which are usually incorporated into the design process and the documentation.
End Item Documentation	IPC-D-325	Documentation depicting bare board specific end product requirements designed by the customer or end item assembly requirements. Details may or may not reference industry specifications or workmanship standards as well as customers own preferences or internal standard requirements.
End Item Standards	J-STD-001	Requirements for soldered electrical and electronic assemblies depicting minimum end product acceptable characteristics as well as methods for evaluation (test methods) frequency of testing and applicable ability of process control requirements.
Acceptability Standard	IPC-A-610	Pictorial interpretive document indicating various characteristics of the board and/or assembly as appropriate relating to desirable conditions that exceed the minimum acceptable characteristics indicated by the end item performance standard and reflect various out-of-control (nonconforming) conditions to assist the shop process evaluators in judging need for corrective action.
Training Program		Documented training requirements for teaching and learning process procedures and techniques for implementing acceptance requirements of either end item standards, acceptability standards, or requirements detailed on the customer documentation.
Rework and Repair	IPC-7711 IPC-7721	Documentation providing the procedures to accomplish conformal coating and component removal and replacement, solder resist repair, and modification/repair of laminate material, conductors, and plated through holes.

Foreword (cont.)

equivalent requirements, then the acceptance criteria needs to be defined between the customer and supplier.

The illustrations in this document portray specific points noted in the title of each page. A brief description follows each illustration. It is not the intent of this document to exclude any acceptable procedure for component placement or for applying flux and solder used to make the electrical connection; however, the methods used must produce completed solder joints conforming to the acceptability requirements described in this document.

In the case of a discrepancy, the description or written criteria always takes precedence over the illustrations.

1.3 Specialized Designs

IPC-A-610, as an industry consensus document, cannot address all of the possible components and product design combinations. However, the standard does provide criteria for commonly used technologies. Where uncommon or specialized components or technologies are necessary, good judgment should be used while applying the criteria of this standard. However, where similar characteristics exist, this document may provide guidance for product acceptance criteria. Often, unique definition is necessary to consider the specialized characteristics while considering product performance criteria. The development should include customer involvement or consent and the criteria should include agreed definition of product acceptance.

Whenever possible this criteria should be submitted to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.

1.4 Terms & Definitions

Items noted with an * are quoted from IPC-T-50, ''Terms and Definitions for Interconnecting and Packaging Electronic Circuits.''

1.4.1 Classification

Criteria defined in this document reflect three classes, which are as follows:

Class 1 — General Electronic Products

Includes consumer products, some computer and computer peripherals suitable for applications where cosmetic imperfections are not important and the major requirement is function of the completed electronic assembly.

Class 2 — Dedicated Service Electronic Products

Includes communications equipment, sophisticated business machines, and instruments where high performance and extended life is required and for which uninterrupted service is desired but not critical. Certain cosmetic imperfections are allowed.

Class 3 — High Performance Electronic Products

Includes the equipment and products where continued performance or performance-on-demand is critical. Equipment downtime cannot be tolerated and must function when required, such as in life support items or flight control systems. Assemblies in this class are suitable for applications where high levels of assurance are required, service is essential, or the end-use environment may be uncommonly harsh.

1.4.2 The customer has the ultimate responsibility for identifying the class to which his assembly is evaluated. Thus, accept and/or reject decisions must be based on applicable documentation such as contracts, drawings, specifications, standards and reference documents.

1.4.3 Acceptance Criteria

When IPC-A-610 is cited or required by contract as a standalone document for inspection and/or acceptance, the requirements of ANSI/J-STD-001 ''Requirements for Soldered Electrical and Electronic Assemblies'' do not apply (unless separately and specifically required).

In the event of conflict, the following order of precedence applies:

1. Procurement as agreed and documented between customer and vendor.
2. Master drawing or master assembly drawing reflecting the customers detailed requirements.
3. When invoked by the customer or per contractual agreement, IPC-A-610.
4. Other documents to extent specified by the customer.

The user (customer) has the responsibility to specify acceptance criteria. If no criteria is specified, required, or cited, then best manufacturing practice applies. When J-STD-001 and IPC-A-610 or other related documents are cited, the order of precedence is to be defined in the procurement documents.

Criteria are given for each class in four levels of acceptance: Target Condition, Acceptable Condition, and either Defect Condition or Process Indicator Condition.

1.4.3.1 Target Condition

A condition that is close to perfect and in the past has been labeled as ''preferred''; however, it is a desirable condition and not always achievable and may not be necessary to ensure reliability of the assembly in its service environment.

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1.4.3.2 Acceptable Condition

This characteristic indicates a condition that, while not necessarily perfect, will maintain the integrity and reliability of the assembly in its service environment. Acceptable can be slightly better than the minimum end product requirements to allow for shifts in the process.

1.4.3.3 Defect Condition

A defect is a condition that may be insufficient to ensure the form, fit or function of the assembly in its end use environment. Defect conditions will be dispositioned based on design, service, and customer requirements. Disposition may be to rework, repair, scrap, or use as is. ''Use As Is'' may require customer concurrence.

1.4.3.4 Process Indicator Condition

A process indicator is a condition (not a defect) which identifies a characteristic that does not affect the ''form, fit or function'' of a product.

- Such condition is a result of material, design and/or operator/machine related causes that create a condition that neither fully meets the acceptance criteria nor is a defect.
- Process indicators should be monitored as part of the process control system and when the number of process indicators indicate abnormal variation in the process or identify an undersirable trend, then the process should be analyzed. This may result in action to reduce the variation and improve yields.
- Disposition of individual process indicators is not required and affected product should be used as is.
- Process control methodologies are to be used in the planning, implementation and evaluation of the manufacturing processes used to produce soldered electrical and electronic assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements. The manufacturer needs to maintain objective evidence of a current process control/continuous improvement plan that is available for review.

1.4.3.5 Conditions Not Specified

Conditions that are not otherwise specified as defective or as a process indicator are considered acceptable unless it can be established that the condition affects end user defined form, fit or function.

1.4.4 Board Orientation

The following terms are used throughout this document to determine the board side:

1.4.4.1 *Primary Side(s)

That side of a packaging and interconnecting structure (PWB) that is so defined on the master drawing. (It is usually the side that contains the most complex or the most number of components. This side is sometimes referred to as the component side or solder destination side in through-hole mounting technology.)

1.4.4.2 *Secondary Side(s)

That side of a packaging and interconnecting structure (PWB) that is opposite the primary side. (This side is sometimes referred to as the solder side or solder source side in through-hole mounting technology.)

1.4.4.3 Solder Source Side

The solder source side is that side of the PWB to which solder is applied. The solder source side is normally the secondary side of the PWB when wave, dip, or drag soldering are used. The solder source side may be the primary side of the PWB when hand soldering operations are conducted. The source/destination side must be considered when applying some criteria, such as that in Table 6-2.

1.4.4.4 Solder Destination Side

The solder destination side is that side of the PWB that the solder flows toward. The destination is normally the primary side of the PWB when wave, dip or drag soldering are used. The destination side may be the secondary side of the PWB when hand-soldering operations are conducted. The source/destination side must be considered when applying some criteria, such as that in Table 6-2.

1.4.5 Electrical Clearance

The minimum spacing between non-common uninsulated conductors (e.g., patterns, materials, hardware, residue) is referred to as ''minimum electrical clearance'' throughout this document and is defined in the applicable design standard or on the approved or controlled documentation. Insulating material must provide sufficient electrical isolation. In the absence of a known design standard use Appendix A (derived from IPC-2221).

1.4.6 *Cold Solder Connection

A solder connection that exhibits poor wetting and that is characterized by a grayish porous appearance. (This is due to

Foreword (cont.)

excessive impurities in the solder, inadequate cleaning prior to soldering, and/or the insufficient application of heat during the soldering process.)

1.4.7 *Leaching

The loss or removal of a basis metal or coating during a soldering operation.

1.4.8 Meniscus (Component)

Sealant or encapsulant on a lead, protruding from the seating plane of the component. This includes materials such as ceramic, epoxy or other composites, and flash from molded components.

1.5 Examples and Illustrations

Many of the examples (illustrations) shown are grossly exaggerated in order to depict the reasons for this classification.

A defect for Class 1 automatically implies a defect for Class 2 and 3. A defect for Class 2 implies a defect for Class 3.

It is necessary that users of this standard pay particular attention to the subject of each section to avoid misinterpretation.

1.6 Inspection Methodology

Accept and/or reject decisions must be based on applicable documentation such as contract, drawings, specifications and referenced documents.

The inspector does not select the class for the assembly under inspection. Documentation that specifies the applicable class for the assembly under inspection is to be provided to the inspector.

Automated Inspection Technology (AIT) is a viable alternative to visual inspection and complements automated test equipment. Many of the characteristics in this document can be inspected with an AIT system. IPC-AI-641 ‘‘User’s Guidelines for Automated Solder Joint Inspection Systems’’ and IPC-AI-642 ‘‘User’s Guidelines for Automated Inspection of Artwork, Inner-layers, and Unpopulated PWBs’’ provide more information on automated inspection technologies.

If the customer desires the use of industry standard requirements for frequency of inspection and acceptance, J-STD-001 is recommended for further soldering requirement details.

1.7 Verification of Dimensions

The actual measurements provided in this document (i.e., specific part mounting and solder fillet dimensions and determination of percentages) are not required except for referee purposes.

1.8 Magnification Aids and Lighting

For visual inspection, some individual specifications may call for magnification aids for examining printed board assemblies.

The tolerance for magnification aids is ± 15% of the selected magnification power. Magnification aids used for inspection need to be appropriate with the item being processed. Lighting needs to be adequate for the magnification aids used. The magnification used to inspect solder connections is based on the minimum width of the land used for the device being inspected. When magnification is required by contract, the magnifications in Table 1-2 apply.

Table 1-2 Inspection Magnification

Land Widths or Land Diameters	Inspection Magnification Power	Referee Magnification Power
>1.0 mm [0.039 in]	1.75X	4X
0.5 to 1.0 mm [0.020 to 0.039 in]	4X	10X
0.25 to 0.5 mm [0.00984 to 0.020 in]	10X	20X
<0.25 mm [0.00984 in]	20X	40X

Referee conditions are used to verify product rejected at the inspection magnification power. For assemblies with mixed land widths, the greater magnification may be used for the entire assembly.

2 Applicable Documents

The following documents of the issue currently in effect form a part of this document to the extent specified herein.

2.1 IPC Documents

IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits

IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies

IPC-DW-425 Design and End Product Requirements for Discrete Wiring Boards

IPC-DW-426 Guidelines for Acceptability of Discrete Wiring Assemblies

IPC-TR-474 An Overview of Discrete Wiring Techniques

IPC-A-600 Acceptability of Printed Boards

IPC-AI-641 User's Guidelines for Automated Solder Joint Inspection Systems

IPC-AI-642 User's Guidelines for Automated Inspection of Artwork, Inner-layers, and Unpopulated PWBs

IPC-TM-650 Test Methods Manual

2.4.22 Bow and Twist (Percentage)

2.4.28.1 Adhesion, Solder Resist (Mask), Tape Test Method

IPC-CM-770 Component Mounting Guidelines for Printed Boards

IPC-SM-782 Surface Mount Design Land Pattern Standard

IPC-CC-830 Qualification and Performance of electrical Insulating Compound for Printed Board Assemblies

IPC-SM-840 Qualification and Performance of Permanent Solder Mask

IPC-SM-785 Guidelines for Accelerated Reliability Testing of Surface Mount Attachments

IPC-2221 Generic Standard on Printed Board Design

IPC-2222 Sectional Standard for Rigid PWB Design

IPC-6011 Generic Performance Specification for Printed Boards

IPC-6012 Qualification and Performance Specification for Rigid Printed Boards

IPC-7711 Rework of Electronic Assemblies

IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

2.2 Joint Industry Documents

IPC/EIA J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies

IPC/EIA J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires

J-STD-003 Solderability Tests for Printed Boards

J-STD-004 Requirements for Soldering Fluxes

IPC/JEDEC J-STD-020 Moisture/Reflow Sensitivity Classification for Plastic Integrated Circuit Surface Mount Devices

IPC/JEDEC J-STD-033 Standard for Handling, Packing, Shipping and Use of Moisture Sensitive Surface Mount Devices

2.3 EOS/ESD Association Documents

ANSI/ESD S8.1 ESD Awareness Symbols

ANSI/ESD-S-20.20 Protection of Electrical and Electronic Parts, Assemblies and Equipment

2.4 Electronics Industries Alliance Documents

EIA-471 Symbol and Label for Electrostatic Sensitive Devices

2.5 International Electrotechnical Commission Documents

IEC/TS 61340-5-1 Protection of Electronic Devices from Electrostatic Phenomena - General Requirements

IEC/TS 61340-5-2 Protection of Electronic Devices from Electrostatic Phenomena - User Guide

Recommended Practices for Handling Electronic Assemblies

Electrostatic Discharge (ESD) is the rapid discharge of electrical energy that was created from electrostatic sources. When electrical energy is allowed to come in contact with or even close to a sensitive component it can cause damage to the component. Electrostatic Discharge Sensitive (ESDS) components are those components that are affected by these high-energy surges. The relative sensitivity of a component to ESD is dependent upon its construction and materials. As components become smaller and operate faster, the sensitivity increases.

Electrical Overstress (EOS) is the internal result of an unwanted application of electrical energy that results in damaged components. This damage can be from many different sources, such as electrically powered process equipment or ESD occurring during handling or processing.

ESDS components can fail to operate or change in value as a result of improper handling or processing. These failures can be immediate or latent. The result of immediate failure can be additional testing and rework or scrap. However the consequences of latent failure are the most serious. Even though the product may have passed inspection and functional test, it may fail after it has been delivered to the customer.

It is important to build protection for ESDS components into circuit designs and packaging. In the manufacturing and assembly areas, work is often done with unprotected electronic assemblies (such as test fixtures) that are attached to the ESDS components. It is important that ESDS items be removed from their protective enclosures only at EOS/ESD safe workstations within Electrostatic Protected Areas (EPA). This section is dedicated to safe handling of these unprotected electronic assemblies.

For that purpose, the following subjects are addressed:

Information in this section is intended to be general in nature. Additional information can be found in ANSI/ESD-S-20.20 and other related documents.

3.1 Electrical Overstress (EOS) Damage Prevention

Electrical components can be damaged by unwanted electrical energy from many different sources. This unwanted electrical energy can be the result of ESD potentials or the result of electrical spikes caused by the tools we work with, such as soldering irons, soldering extractors, testing instruments or other electrically operated process equipment. Some devices are more sensitive than others. The degree of sensitivity is a function of the design of the device. Generally speaking, higher speed and smaller devices are more susceptible than their slower, larger predecessors. The purpose or family of the device also plays an important part in component sensitivity. This is because the design of the component can allow it to react to smaller electrical sources or wider frequency ranges. With today's products in mind, we can see that EOS is a more serious problem than it was even a few years ago. It will be even more critical in the future.

When considering the susceptibility of the product, we must keep in mind the susceptibility of the most sensitive component in the assembly. Applied unwanted electrical energy can be processed or conducted just as an applied signal would be during circuit performance.

Before handling or processing sensitive components, tools and equipment need to be carefully tested to ensure that they do not generate damaging energy, including spike voltages. Current research indicates that voltages and spikes less than 0.5 volt are acceptable. However, an increasing number of extremely sensitive components require that soldering irons, solder extractors, test instruments and other equipment must never generate spikes greater than 0.3 volt.

As required by most ESD specifications, periodic testing may be warranted to preclude damage as equipment performance may degrade with use over time. Maintenance programs are also necessary for process equipment to ensure the continued ability to not cause EOS damage.

EOS damage is certainly similar in nature to ESD damage, since damage is the result of undesirable electrical energy.

3.2 Electrostatic Discharge (ESD) Damage Prevention

Table 3-1 Typical Static Charge Sources

Work surfaces	Waxed, painted or varnished surfaces Untreated vinyl and plastics Glass
Floors	Sealed concrete Waxed or finished wood Floor tile and carpeting
Clothes and personnel	Non-ESD smocks Synthetic materials Non-ESD Shoes Hair
Chairs	Finished wood Vinyl Fiberglass Nonconductive wheels
Packaging and handling materials	Plastic bags, wraps, envelopes Bubble wrap, foam Styrofoam Non-ESD totes, trays, boxes, parts bins
Assembly tools and materials	Pressure sprays Compressed air Synthetic brushes Heat guns, blowers Copiers, printers

Table 3-2 Typical Static Voltage Generation

Source	10-20% humidity	65-90% humidity
Walking on carpet	35,000 volts	1,500 volts
Walking on vinyl flooring	12,000 volts	250 volts
Worker at a bench	6,000 volts	100 volts
Vinyl envelopes (Work Instructions)	7,000 volts	600 volts
Plastic bag picked up from the bench	20,000 volts	1,200 volts
Work chair with foam pad	18,000 volts	1,500 volts

The best ESD damage prevention is a combination of preventing static charges and eliminating static charges if they do occur. All ESD protection techniques and products address one or both of the two issues.

ESD damage is the result of electrical energy that was generated from static sources either being applied or in close proximity to ESDS devices. Static sources are all around us. The degree of static generated is relative to the characteristics of the source. To generate energy, relative motion is required. This could be contacting, separation, or rubbing of the material.

Most of the serious offenders are insulators since they concentrate energy where it was generated or applied rather than allowing it to spread across the surface of the material. See Table 3-1. Common materials such as plastic bags or Styrofoam containers are serious static generators and as such are not to be allowed in processing areas especially static safe/ Electrostatic Protected Areas (EPA). Peeling adhesive tape from a roll can generate 20,000 volts. Even compressed air nozzles that move air over insulating surfaces generate charges.

Destructive static charges are often induced on nearby conductors, such as human skin, and discharged into conductors on the assembly. This can happen when a person having an electrostatic charge potential touches a printed board assembly. The electronic assembly can be damaged as the discharge passes through the conductive pattern to an ESDS component. Electrostatic discharges may be too low to be felt by humans (less than 3500 volts), and still damage ESDS components.

Typical static voltage generation is included in Table 3-2.

3.2.1 ESD Damage Prevention – Warning Labels

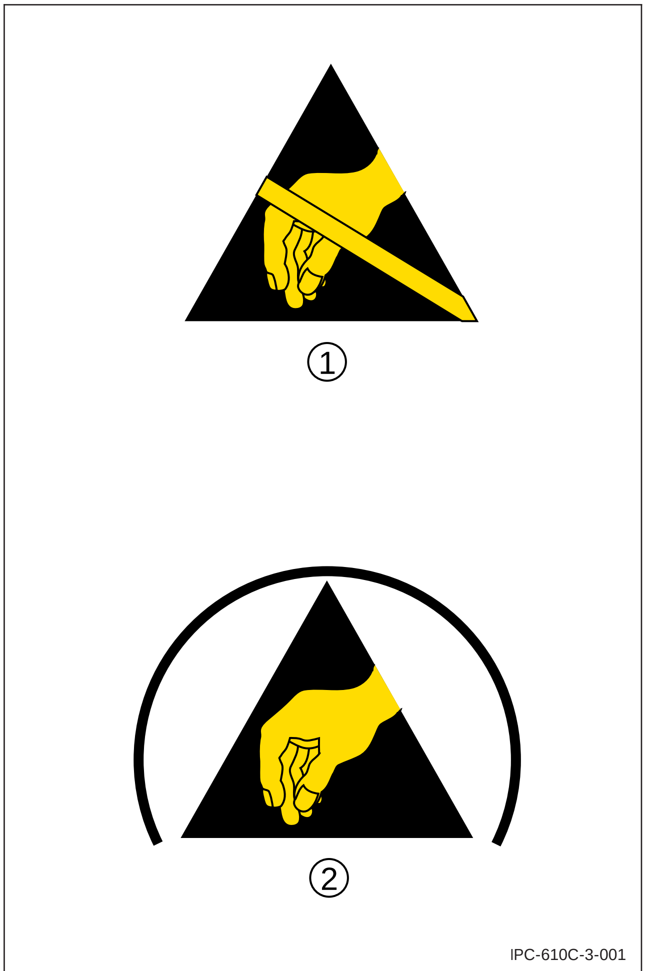

Figure 3-1
1. ESD Susceptibility Symbol
2. ESD Protective Symbol

Warning labels are available for posting in facilities and placement on devices, assemblies, equipment and packages to alert people to the possibility of inflicting electrostatic or electrical overstress damage to the devices they are handling. Examples of frequently encountered labels are shown in Figure 3-1.

Symbol (1) ESD susceptibility symbol. A triangle with a reaching hand and a slash across it. This is used to indicate that an electrical or electronic device or assembly is susceptible to damage from an ESD event.

Symbol (2) ESD protective symbol. This differs from the ESD susceptibility symbol in that it has an arc around the outside of the triangle and no slash across the hand. This is used to identify items that are specifically designed to provide ESD protection for ESD sensitive assemblies and devices.

Symbols (1) and (2) identify devices or an assembly as containing devices that are ESD sensitive, and that they must be handled accordingly. These symbols are promoted by the ESD association and are described in EOS/ESD standard S8.1 as well as the Electronic Industries Association (EIA) in EIA-471 and IEC/TS 61340-5-1.

Note that the absence of a symbol does not necessarily mean that the assembly is not ESD sensitive. ***When doubt exists about the sensitivity of an assembly, it must be handled as a sensitive device until it is determined otherwise.***

3.2.2 ESD Damage Prevention – Protective Materials

ESDS components and assemblies must be protected from static sources when not being worked on in static safe environments or workstations. This protection could be conductive static-shielding boxes, bags or wraps.

ESDS items must be removed from their protective enclosures only at static safe workstations.

It is important to understand the difference between the three types of protective enclosure material: (1) static shielding (or barrier packaging), (2) antistatic, and (3) static dissipative materials.

Static shielding packaging will prevent an electrostatic discharge from passing through the package and into the assembly causing damage.

Antistatic (low charging) packaging materials are used to provide inexpensive cushioning and intermediate packaging for ESDS items. Antistatic materials do not generate charges when motion is applied. However, if an electrostatic discharge occurs, it could pass through the packaging and into the part or assembly, causing EOS/ESD damage to ESDS components.

Static dissipative materials have enough conductivity to allow applied charges to dissipate over the surface relieving hot spots of energy. Parts leaving an EOS/ESD protected work area must be overpacked in static shielding materials, which normally also have static dissipative and antistatic materials inside.

Do not be misled by the ‘‘color’’ of packaging materials. It is widely assumed that ‘‘black’’ packaging is static shielding or conductive and that ‘‘pink’’ packaging is antistatic in nature. While that may be generally true, it can be misleading. In addition, there are many new clear materials now on the market that may be antistatic and even static shielding. At one time, it could be assumed that clear packing materials introduced into the manufacturing operation would represent an EOS/ESD hazard. This is not necessarily the case now.

Caution:

Some static shielding and antistatic materials and some topical antistatic solutions may affect the solderability of assemblies, components, and materials in process. Select only non-contaminating packaging and handling materials for in-process assemblies and use them with regard for the vendors instructions. Solvent cleaning of static dissipative or antistatic surfaces can degrade their ESD performance. Follow the manufacturer’s recommendations for cleaning.

3.3 EOS/ESD Safe Workstation/EPA

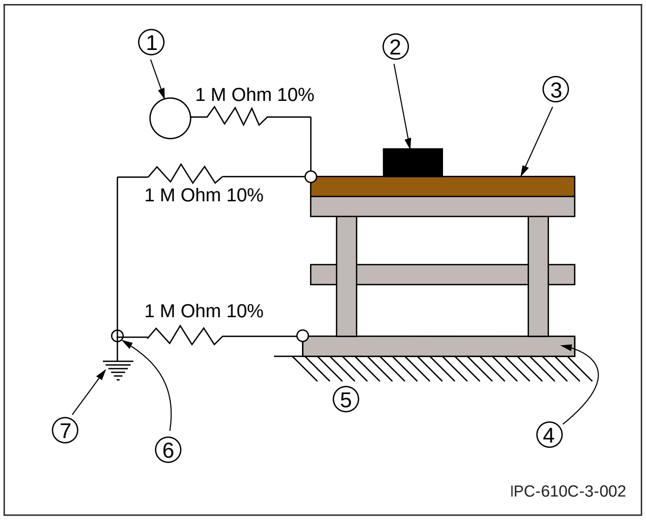

Figure 3-2 Series Connected Wrist Strap

1. Personal wrist strap
2. EOS protective trays, shunts, etc.
3. EOS protective table top
4. EOS protective floor or mat
5. Building floor
6. Common ground point
7. Ground

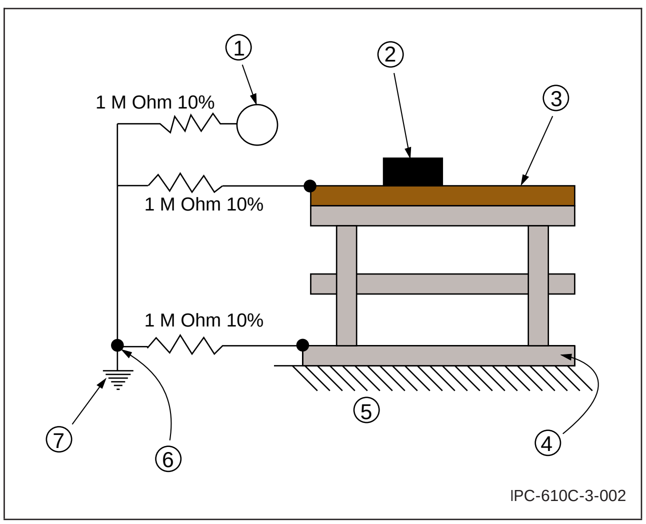

Figure 3-3 Parallel Connected Wrist Strap

1. Personal wrist strap
2. EOS protective trays, shunts, etc.
3. EOS protective table top
4. EOS protective floor or mat
5. Building floor
6. Common ground point
7. Ground

An EOS/ESD safe workstation prevents damage to sensitive components from spikes and static discharges while operations are being performed. Safe workstations should include EOS damage prevention by avoiding spike generating repair, manufacturing or testing equipment. Soldering irons, solder extractors and testing instruments can generate energy of sufficient levels to destroy extremely sensitive components and seriously degrade others.

For ESD protection, a path-to-ground must be provided to neutralize static charges that might otherwise discharge to a device or assembly. ESD safe workstations/EPAs also have static dissipative or antistatic work surfaces that are connected to a common ground. Provisions are also made for grounding the worker's skin, preferably via a wrist strap to eliminate charges generated on the skin or clothing.

Provision must be made in the grounding system to protect the worker from live circuitry as the result of carelessness or equipment failure. This is commonly accomplished through resistance in line with the ground path, which also slows the charge decay time to prevent sparks or surges of energy from ESD sources. Additionally, a survey must be performed of the available voltage sources that could be encountered at the workstation to provide adequate protection from personnel electrical hazards.

For maximum allowable resistance and discharge times for static safe operations, see Table 3-3.

Table 3-3 Maximum Allowable Resistance and Discharge Times for Static Safe Operations

Reading from Operator Through	Maximum Tolerable Resistance	Maximum Acceptable Discharge Time
Floor mat to ground	1000 megohms	less than 1 sec.
Table mat to ground	1000 megohms	less than 1 sec.
Wrist strap to ground	100 megohms	less than 0.1 sec.

Note: The selection of resistance values are to be based on the available voltages at the station to ensure personnel safety as well as to provide adequate decay or discharge time for ESD potentials.

Examples of acceptable workstations are shown in Figures 3-2 and 3-3. When necessary, air ionizers may be required for more sensitive applications. The selection, location, and use procedures for ionizers must be followed to ensure their effectiveness.

3.3 EOS/ESD Safe Workstation/EPA (cont.)

Keep workstation(s) free of static generating materials such as styrofoam, plastic solder removers, sheet protectors, plastic or paper notebook folders, and employees' personal items.

Periodically check workstations/EPAs to make sure they work. EOS/ESD assembly and personnel hazards can be caused by improper grounding methods or by an oxide build-up on grounding connectors. Tools and equipment must be periodically checked and maintained to ensure proper operation.

Note: Because of the unique conditions of each facility, particular care must be given to ''third wire'' ground terminations.

Frequently, instead of being at workbench or earth potential, the third wire ground may have a ''floating'' potential of 80 to 100 volts. This 80 to 100 volt potential between an electronic assembly on a properly grounded EOS/ESD workstation/EPA and a third wire grounded electrical tool may damage EOS sensitive components or could cause injury to personnel. Most ESD specifications also require these potentials to be electrically common. The use of ground fault interrupter (GFI) electrical outlets at EOS/ESD workstations/EPAs is highly recommended.

3.4 Handling

3.4.1 Handling – Guidelines

Care must be taken during acceptability inspections to ensure product integrity at all times. Table 3-4 provides general guidance.

Moisture sensitive components (as classified by IPC/JEDEC J-STD-020 or equivalent documented procedure) must be handled in a manner consistent with J-STD-033 or an equivalent documented procedure.

Table 3-4 General Rules for Handling Electronic Assemblies

1. Keep workstations clean and neat. There must not be any eating, drinking, or use of tobacco products in the work area.
2. Minimize the handling of electronic assemblies and components to prevent damage.
3 When gloves are used, they need to be changed as frequently as necessary to prevent contamination from dirty gloves; see Figure 3-4.
4. Solderable surfaces are not to be handled with bare hands or fingers. Body oils and salts reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulates.
5. Do not use hand creams or lotions containing silicone since they can cause solderability and conformal coating adhesion problems.
6. Never stack electronic assemblies or physical damage may occur. Special racks need to be provided in assembly areas for temporary storage.
7. Always assume the items are ESDS even if they are not marked.
8. Personnel must be trained and follow appropriate ESD practices and procedures.
9. Never transport ESDS devices unless proper packaging is applied.

3.4.2 Handling – Physical Damage

Improper handling can readily damage components and assemblies (e.g., cracked, chipped or broken components and connectors, bent or broken terminals, badly scratched board surfaces and conductor lands). Physical damage of this type can ruin the entire assembly or attached components.

3.4.3 Handling – Contamination

Contamination by handling with bare hands or fingers without some form of protection may cause soldering and coating problems; body salts and oils, and unauthorized hand creams are typical contaminants. Body oils and acids reduce solderability, promote corrosion and dendritic growth. They can also cause poor adhesion of subsequent coatings or encapsulates. Lotion formulated specifically for use in solder assembly areas is available. Normal cleaning procedures will not always remove such contaminants. The best solution is to prevent contamination.

3.4.4 Handling – Electronic Assemblies

Even if no ESDS markings are on an assembly, it still needs to be handled as if it were an ESDS assembly. However, ESDS components and electronic assemblies need to be identified by suitable EOS/ESD labels (see Figure 3-1). Many sensitive assemblies will also be marked on the assembly itself, usually on an edge connector. To prevent ESD and EOS damage to sensitive components, all handling, unpacking, assembly and testing must be performed at a static controlled workstation (see Figures 3-2 and 3-3).

Avoid contaminating solderable surfaces prior to soldering. Whatever comes in contact with these surfaces must be clean. When boards are removed from their protective wrappings, handle them with great care. Touch only the edges away from any edge connector tabs. Where a firm grip on the board is required due to any mechanical assembly procedure, gloves meeting EOS/ESD requirements need to be worn. These principles are especially critical when no-clean processes are employed.

3.4.5 Handling – After Soldering

After soldering and cleaning operations, the handling of electronic assemblies still requires great care. Fingerprints are extremely hard to remove and will often show up in conformally coated boards after humidity or environmental testing. Gloves or other protective handling devices need to be used to prevent such contamination. Use mechanical racking or baskets with full ESD protection when handling during cleaning operations.

3.4.6 Handling – Gloves and Finger Cots

The use of gloves or finger cots may be required under contract to prevent contamination of parts and assemblies. Gloves and finger cots must be carefully chosen to maintain EOS/ESD protection.

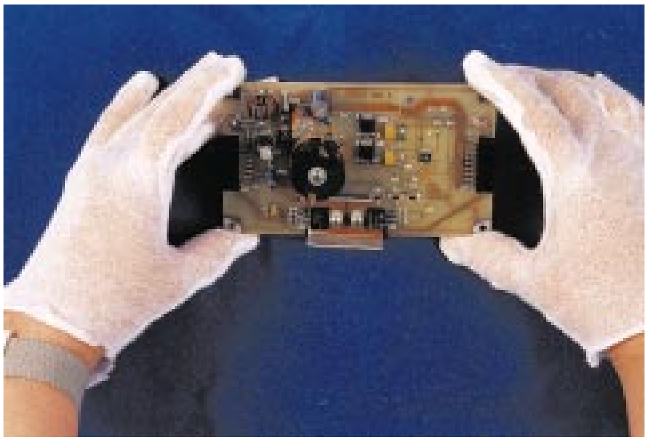

Figure 3-4

Target - Class 1,2,3

- Handling with clean gloves and full EOS/ESD protection.
- Handling during cleaning procedures using solvent resistant gloves meeting all EOS/ESD requirements.

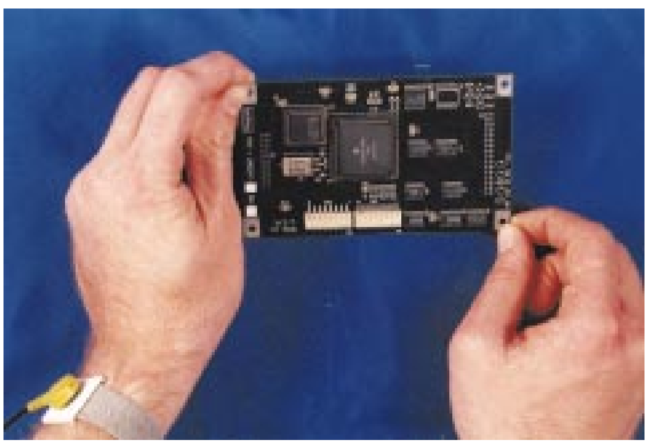

Figure 3-5

Acceptable - Class 1,2,3

- Handling with clean hands by board edges using full EOS/ESD protection.

Note: Any assembly related component if handled without EOS/ESD protection may damage electrostatic sensitive components. This damage could be in the form of latent failures, or product degradation not detectable during initial test or catastrophic failures found at initial test.

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Mechanical Assembly

Mechanical assembly refers to mounting electronic devices to a printed wiring board (PWB) or any other types of assemblies requiring the use of any of the following: screws, bolts, nuts, washers, fasteners, clips, component studs, adhesives, tie downs, rivets, connector pins, etc.

This section is primarily concerned with proper securing (tightness), and also with checking for damage to the devices, hardware, and the mounting surface that can result from mechanical assembly.

This section covers visual criteria. Compliance to torque requirements is to be verified as specified by customer documentation. The verification procedure ensures that no damage to components or assembly occurs. Where torque requirements are not specified, follow standard industry practices.

The following topics are addressed in this section:

4.1 Hardware

This section illustrates several types of mounting hardware.

Process documentation will specify what to use (drawings, prints, parts list, build process); deviations need to have prior customer approval.

Visual inspection is performed in order to verify the following conditions:

a. Correct parts and hardware.
b. Correct sequence of assembly.
c. Correct security and tightness of parts and hardware.
d. No discernible damage.
e. Correct orientation of parts and hardware.

4.2 Hardware Mounting

4.2.1 Hardware Mounting – Electrical Clearance (1.4.10)

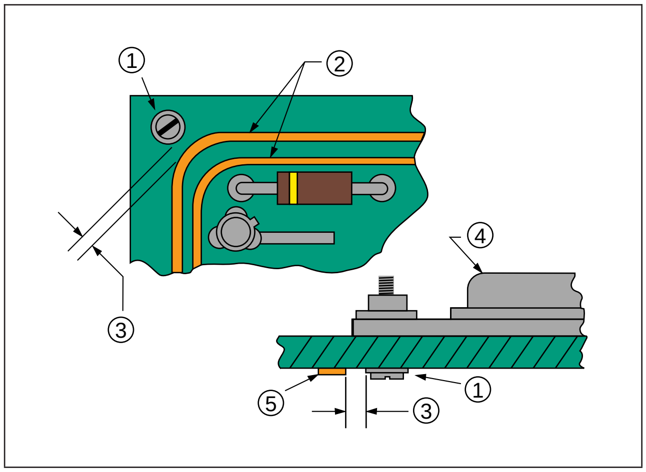

Figure 4-1
1. Metallic hardware
2. Conductive pattern
3. Specified minimum electrical clearance
4. Mounted component
5. Conductor

Acceptable - Class 1,2,3

- Specified minimum electrical clearance. Shown in this example as the distances between 1 & 2 and 1 & 5.

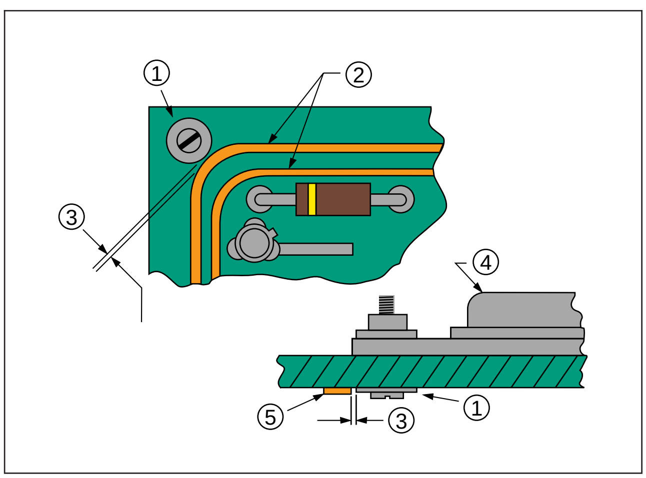

Figure 4-2
1. Metallic hardware
2. Conductive pattern
3. Spacing less than electrical clearance requirements
4. Mounted component
5. Conductor

Defect - Class 1,2,3

- Hardware reduces spacing to less than specified minimum electrical clearance.

4.2.2 Hardware Mounting – Excess Solder

Figure 4-3

Defect - Class 1,2,3

- Excess solder (uneven) on mounting holes where mechanical assembly will be affected.

4.2.3 Hardware Mounting – Threaded Fasteners

A minimum of one and one half threads need to extend beyond the threaded hardware, (e.g., nut) unless otherwise specified by engineering drawing. Bolts or screws may be flush with the end of the threaded hardware only where threads could interfere with other components or wires and when locking mechanisms are used.

Thread extension should not be more than 3.0 mm [0.12 in] plus one and one-half threads for bolts or screws up to 25 mm [0.984 in] long or more than 6.3 mm [0.248 in] plus one and one-half threads for bolts or screws over 25 mm [0.984 in]. This is providing that the extension does not interfere with any adjacent part and that the designed electrical clearance requirements are met.

4.2.3 Hardware Mounting – Threaded Fasteners (cont.)

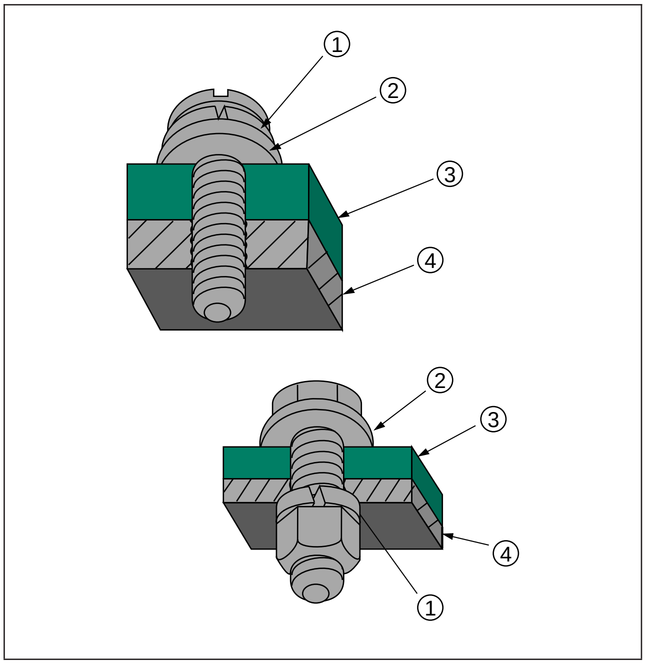

Figure 4-4
1. Lock washer
2. Flat washer
3. Nonconductive material (laminate, etc.)
4. Metal (not conductive pattern or foil)

Acceptable - Class 1,2,3

- Proper hardware sequence.

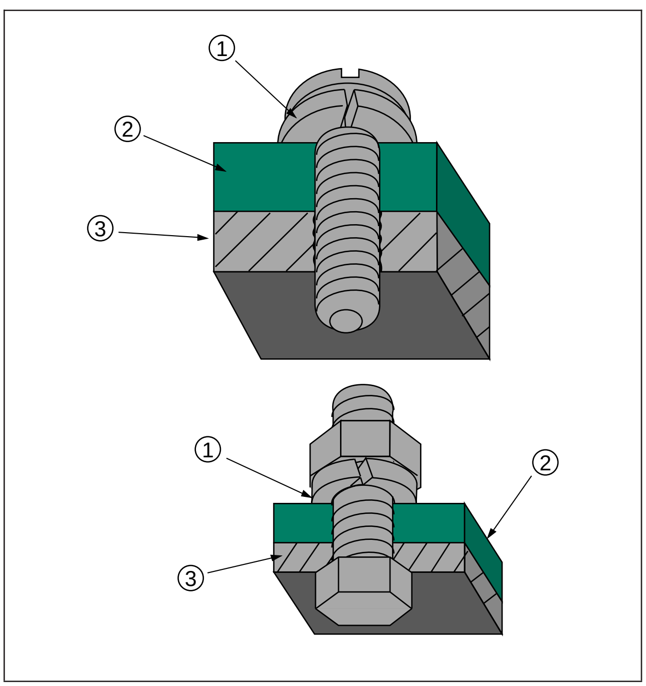

Figure 4-5
1. Lock washer
2. Nonmetal
3. Metal (not conductive pattern or foil)

Defect - Class 1,2,3

- Lock washer against nonmetal/laminate.
- Flat washer missing.

4.2.3 Hardware Mounting – Threaded Fasteners (cont.)

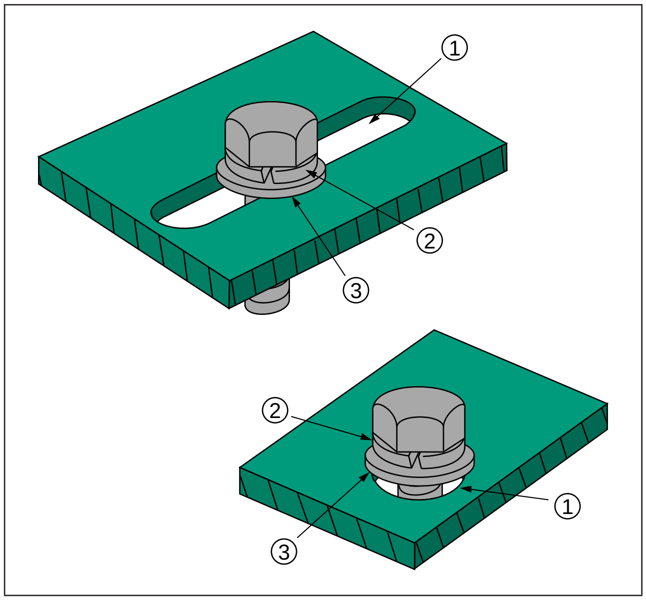

Figure 4-6
1. Slot or hole
2. Lock washer
3. Flat washer

Acceptable - Class 1,2,3

- Slot is covered with flat washer.
- Hole is covered with flat washer.

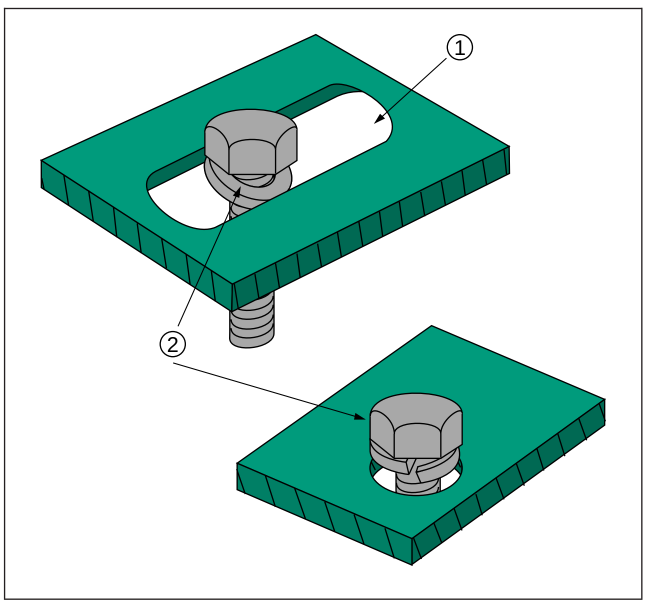

Figure 4-7
1. Slot or hole
2. Lock washer

Defect - Class 1,2,3

- Hardware missing or improperly installed.

4.2.3.1 Hardware Mounting – Threaded Fasteners – Minimum Torque for Electrical Connections

When electrical connections are made using threaded fasteners they must be tight to ensure the reliability of the connection. When split-ring type lock washers are used, the threaded fastener must be tight enough to compress the lock washer. When required, fasteners are tightened to the specified minimum torque value.

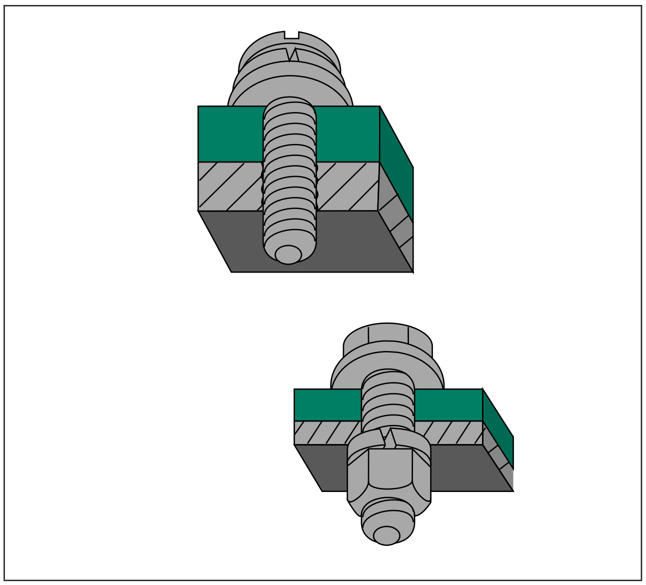

Figure 4-8

Acceptable - Class 1,2,3

- Fasteners are tight and split-ring lock washers, when used, are fully compressed.
- Proper torque applied when torque is a requirement.

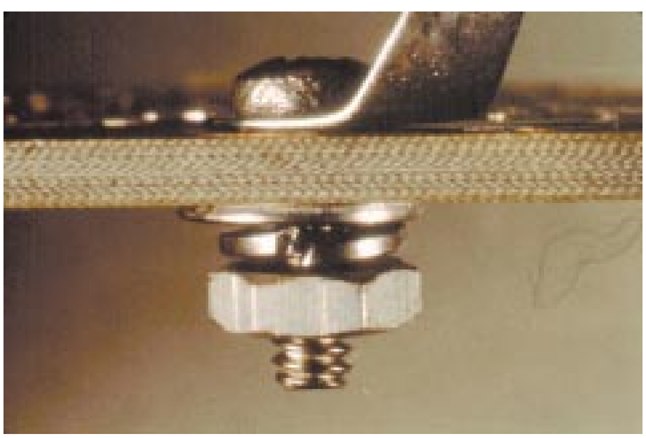

Figure 4-9

Defect - Class 1,2,3

- Lock washer not compressed.

4.2.3.2 Hardware Mounting – Threaded Fasteners – Wires

When the use of terminal lugs is not required, wires are wrapped around screw type terminals in a manner that precludes loosening when the screw is tightened, and the ends of the wire are kept short to preclude shorting to ground or other current carrying conductors.

If a washer is used, the wire/lead is to be mounted under the washer.

Unless otherwise noted, all requirements apply to both stranded and solid wires.

Figure 4-10

Target - Class 1,2,3

- Strands of wire tightly twisted together (stranded wire).
- Wire wrapped a minimum of 270° around the screw body.
- Wire end secured under screw head.
- Wire wrapped in the correct direction.
- All strands are under screw head.

4.2.3.2 Hardware Mounting – Threaded Fasteners – Wires (cont.)

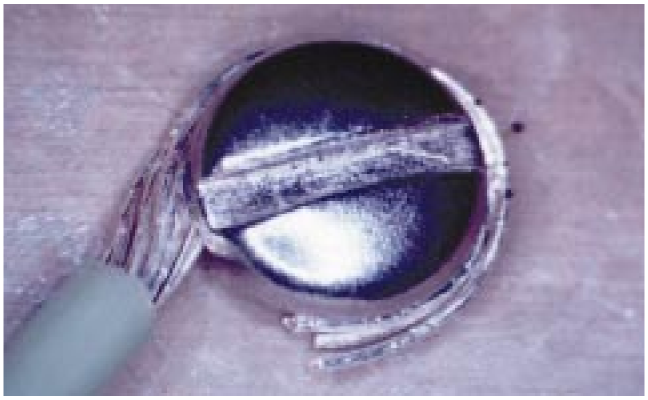

Figure 4-11

Figure 4-12

Acceptable - Class 1,2,3

- Wire wrapped around the screw body in the correct direction, but a few strands have unraveled in tightening the screw.
- Less than 1/3 of the wire diameter protrudes from under the screw head.
- Wire extending outside the screw head does not violate minimum electrical clearance.
- Mechanical attachment of the wire is in contact between the screw head and the contact surface for a minimum of 180° around the screw head.
- No insulation in the contact area.
- Wire does not overlap itself.

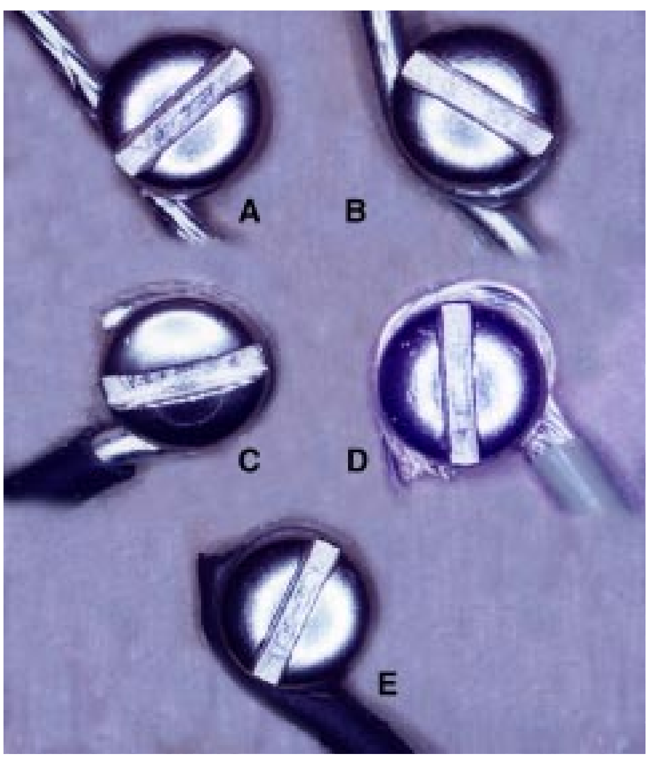

Figure 4-13

Defect - Class 1,2,3

A. Wire not wrapped around screw body.
B. Wire is overlapped.
C. Solid wire wrapped in wrong direction.
D. Stranded wire wrapped in wrong direction (tightening the screw unwinds the twisted wire).
E. Insulation in the contact area.

4.2.3.3 Hardware Mounting – Threaded Fasteners – High Voltage Applications

This section provides the unique requirements of mechanical assemblies that are subject to high voltages. See also 6.8.

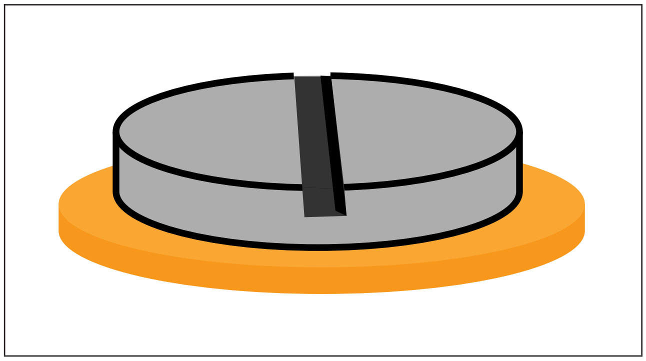

Figure 4-14

Acceptable - Class 1,2,3

• There is no evidence of burrs or frayed edges on the hardware.

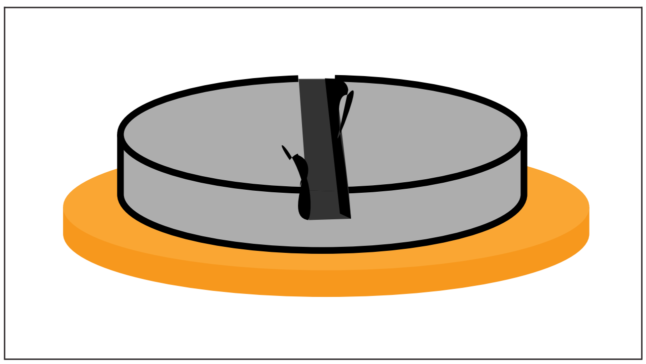

Figure 4-15

Defect - Class 1,2,3

• Hardware has burrs or frayed edges.

4.2.4 Hardware Mounting – Component Installation

4.2.4.1 Hardware Mounting – Component Installation – High Power

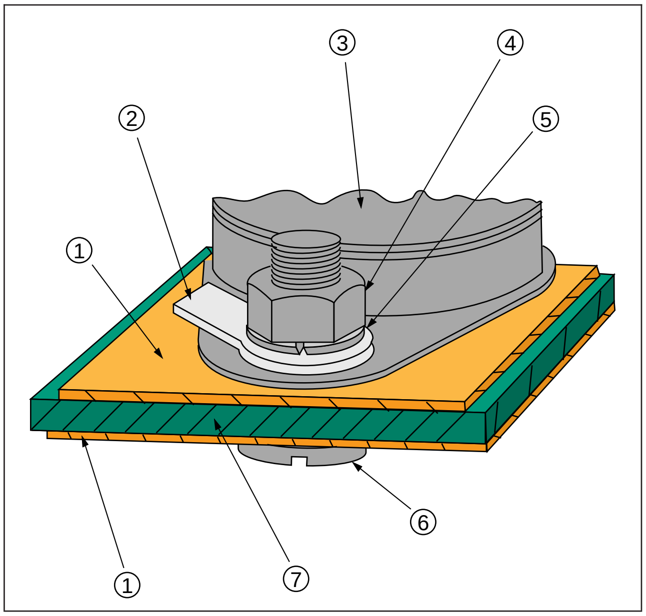

Figure 4-16
1. **Metal**
2. **Terminal lug**
3. **Component case**
4. **Nut**
5. **Lock washer**
6. **Screw**
7. **Nonmetal**

Acceptable - Class 1,2,3

- Hardware in proper sequence.
- Leads on components attached by fastening devices are not clinched. (Not shown)

Note: Where a thermal conductor is specified, it must be placed between mating surfaces of the power device and the heat sink. Thermal conductors may consist of a thermally conductive washer or of an insulating washer with a thermally conductive compound.

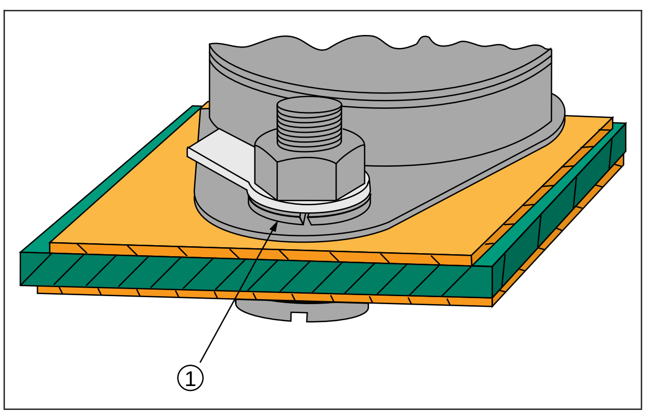

Figure 4-17
1. **Lock washer between terminal lug and component case**

Defect - Class 2,3

- Improper hardware sequence.

4.2.4.1 Hardware Mounting – Component Installation – High Power (cont.)

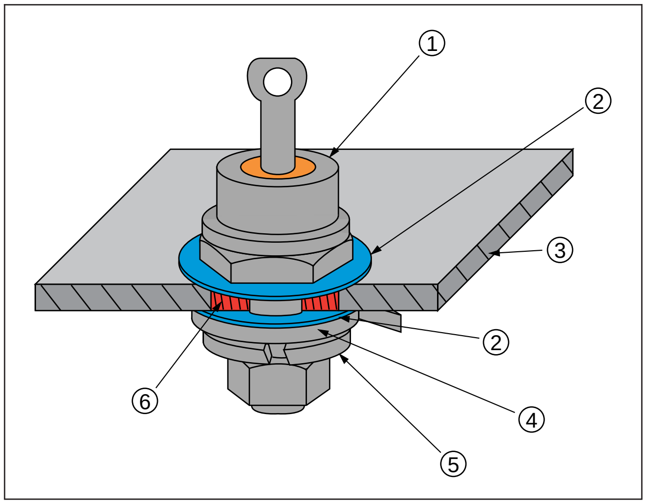

Figure 4-18

1. High power component
2. Insulating washer (when required)
3. Heat sink (may be metal or nonmetal)
4. Terminal lug
5. Lock washer
6. Insulator sleeve

Acceptable - Class 1,2,3

- Insulating washer provides electrical isolation when required.
- Hardware in proper sequence.

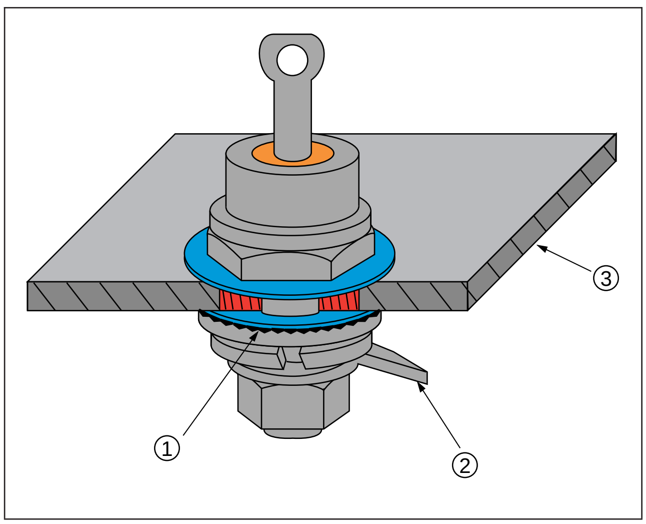

Figure 4-19

1. Sharp edge of washer against insulator
2. Terminal lug
3. Metal heat sink

Defect - Class 1,2,3

- Improper hardware sequence.
- Sharp edge of washer is against insulator.

4.2.4.2 Hardware Mounting – Hole Obstruction of Solder Fill

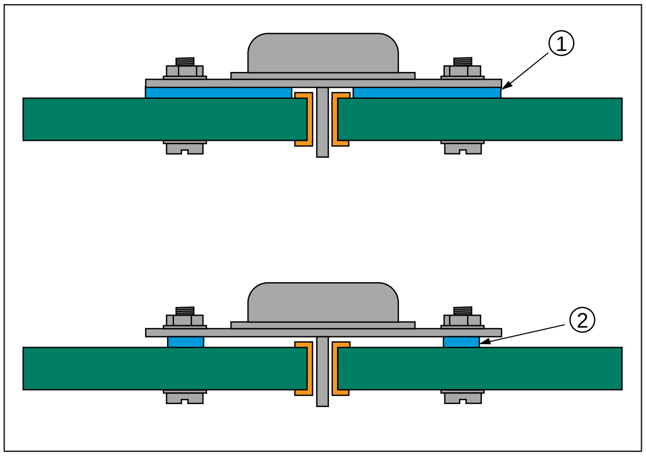

Figure 4-20
1. Insulating washer
2. Spacer

Acceptable - Class 1,2,3

- Parts and components are mounted such that they do not prevent fill of plated-through holes that are required to be soldered.

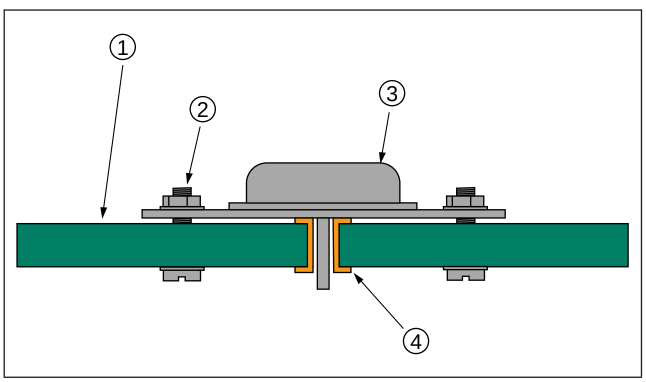

Figure 4-21
1. Nonmetal
2. Mounting hardware
3. Component case
4. Conductive pattern

Process Indicator - Class 2
Defect - Class 3

- Parts and components prevent fill of plated-through holes that are required to be soldered.

4.3 Swaged Hardware

This section contains photographs and illustrations of the basic types of swaged hardware and the characteristics classified by quality levels of criteria.

The photographs of this standard were selected on their merits to indicate a particular characteristic.

Electrical Terminals

Swaged hardware acceptable for electronic assemblies, where they will become a part of the circuitry, should be of pure copper and fully annealed.

Other types of swaged components such as rivets, spacers, standoffs, etc., that are swaged in nonelectrically active holes are not required to meet these requirements.

Solderability

Plating and solderability of swaged hardware should be consistent with appropriate plating and solderability specifications. See IPC/EIA J-STD-002 and J-STD-003 for solderability requirements.

Inspection

Inspection of swaged hardware is generally visual, but microsection methods are recommended for qualification testing.

4.3.1 Swaged Hardware – Flared Flange

The shank extending beyond the land surface is swaged to create an inverted cone, uniform in spread, and concentric to the hole.

The flange is not split, cracked or otherwise discontinuous to the extent that flux, oils, inks, or other liquid substances utilized for processing the printed wiring assemblies can be entrapped within the mounting hole. After swaging, the area is free of circumferential splits or cracks, but may have a maximum of three radial splits or cracks provided that the splits or cracks are separated by at least 90° and do not extend into the barrel of the terminal.

Figure 4-22

Target - Class 1,2,3

- Flared flange is uniformly swaged and concentric to the hole.
- Strain or stress marks caused by flaring are kept to a minimum.
- The flange is swaged sufficiently tight to prevent movement in the Z-axis.

Figure 4-23

Acceptable - Class 1,2,3

- Split in flared flange does not enter into the barrel.

Figure 4-24

Acceptable - Class 1

- Split in flared flange in barrel acceptable if soldered after swaging.

Defect - Class 2,3

- Flared flange periphery uneven or jagged.
- Split enters into barrel.
- Any circumferential splits/cracks.

4.3.1.1 Swaged Hardware – Flared Flange – Controlled Split

This form of swaged hardware is obtained by using scored hardware with a number of uniform segments. When swaged, each segment should conform to a particular angle.

Controlled split hardware is to be soldered as soon as possible after swaging to avoid oxidation.

Figure 4-25

Target - Class 1,2,3

- Flange is uniformly split and concentric to the hole.
- Split segments do not extend to the outside diameter of the land.
- Flange is swaged sufficiently tight to prevent movement in the z-axis.

Figure 4-26

Acceptable - Class 1,2
Defect - Class 3

- Flange splits down to the board but not into the barrel.

4.3.1.1 Swaged Hardware – Flared Flange – Controlled Split (cont.)

Figure 4-27

Figure 4-28

Acceptable - Class 1
Defect - Class 2,3

- Flange damaged.
- Segments excessively deformed.
- One segment missing.
- Split enters into barrel.
- Any circumferential splits/cracks.

Figure 4-29

Defect - Class 1,2,3

- Flange diameter is greater than land diameter.

4.3.2 Swaged Hardware – Flat Flange – Fused-in-Place

The flange is not split, cracked or otherwise discontinuous to the extent that flux, oils, inks, or other liquid substances utilized for processing the printed board can be entrapped within the mounting hole. After swaging, the area is free of circumferential splits or cracks.

The barrel may have solder in it if it is not detrimental to later assembly steps.

The manufactured flange (head) of the eyelet needs to be in full contact with the land area.

Figure 4-30

Target - Class 1,2,3

- Solder around periphery of flange.
- Good filleting of solder around flange.
- Good wetting of flange and terminal area.
- The swaged flange is as close to the land as possible to prevent movement in the z-axis.
- Evidence of solder flow is discernible between flange and land on secondary side of the printed board or other substrate.

4.3.2 Swaged Hardware – Flat Flange – Fused-in-Place (cont.)

Figure 4-31

Acceptable - Class 1,2

- Solder around a minimum of 270° of flange.
- Fillet of solder to at least 75% of flange height.
- Split is filled with solder.

Acceptable - Class 3

- Solder around at least 330° of flange.
- Fillet of solder to at least 75% of flange height.
- No radial or circumferential splits.

Figure 4-32

Defect - Class 1,2,3

- Improperly swaged flange not seated on terminal area.
- Split flange not filled with solder.
- Solder does not reach up to 75% of flange height.
- Solder is less than 270° around flange.

Defect - Class 3

- Solder is less than 330° around flange.
- Any radial or circumferential split in flange.

4.3.3 Swaged Hardware – Terminals

This section shows mechanical assembly of two types of terminals, turret and bifurcated. Terminals that are to be soldered to a land may be mounted so that they can be turned by hand, but are vertically stable.

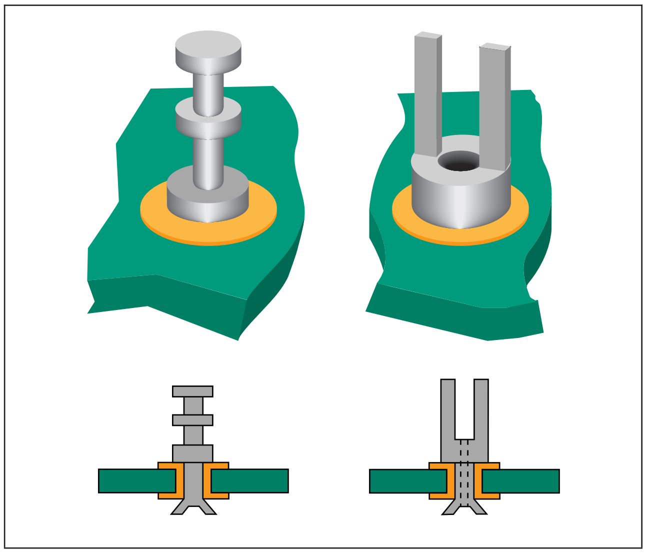

Figure 4-33

Target - Class 1,2,3

- Terminal intact and straight.

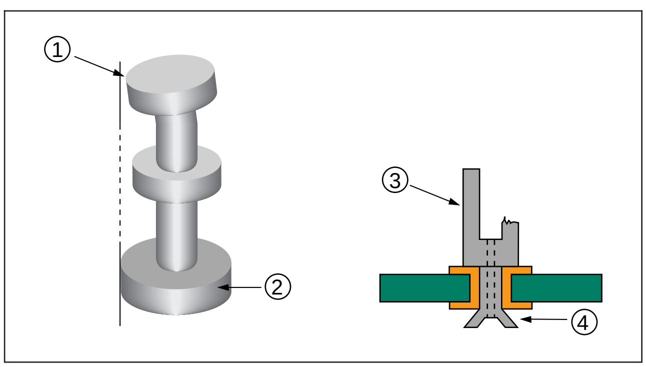

Figure 4-34
1. Top edge
2. Base
3. Post
4. Flange

Acceptable - Class 1,2,3

- Terminal is bent, but the top edge does not extend beyond the base.

Acceptable - Class 1
Defect - Class 2,3

- A post is broken, but sufficient mounting area remains to attach the specified wires/leads.
- The top edge of the terminal is bent beyond the edge of the base.

Defect - Class 1,2,3

- Both posts are broken (bifurcated).
- The center post is fractured (turret terminal).
- Violates minimum electrical clearance.

4.4 Component Mounting

This section illustrates the proper use of mounting clips, adhesives, and wire hold downs.

The placement of any component on the electronic assembly does not prevent the insertion or removal of any hardware (tool clearance included) used to mount the assembly.

Minimum spacing between installed hardware and the conducting land, component leads or uninsulated components depends on specified voltage and is not less than the specified minimum electrical clearance.

Bonding material is sufficient to hold the part but not encapsulate and cover component identification.

Visual inspection includes part identification, assembly sequence, damage to hardware, component, or board.

4.4.1 Component Mounting – Mounting Clips

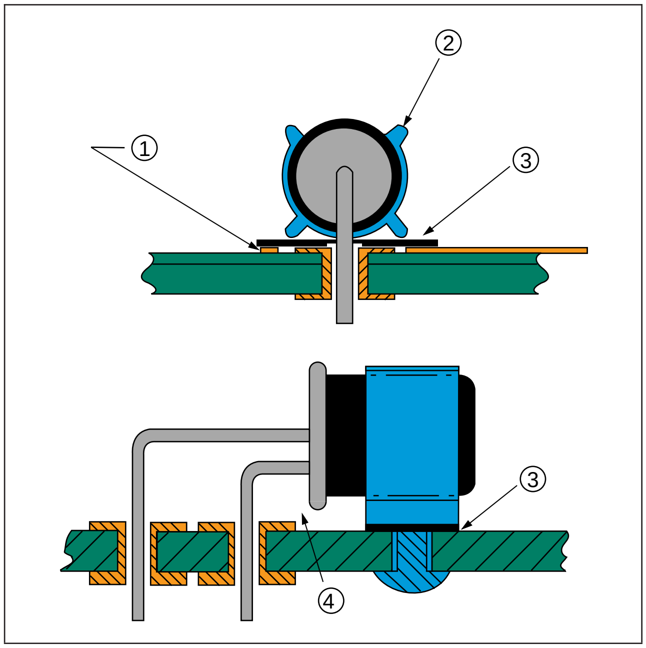

Figure 4-35

1. **Conductive patterns**
2. **Metallic mounting clip**
3. **Insulation material**
4. **Clearance**

Target - Class 1,2,3

- Uninsulated metallic component insulated from underlying circuitry with insulating material.
- Uninsulated metallic clips and holding devices used to secure components insulated from underlying circuitry with suitable insulating material.
- Spacing between land and uninsulated component body exceeds minimum electrical clearance.

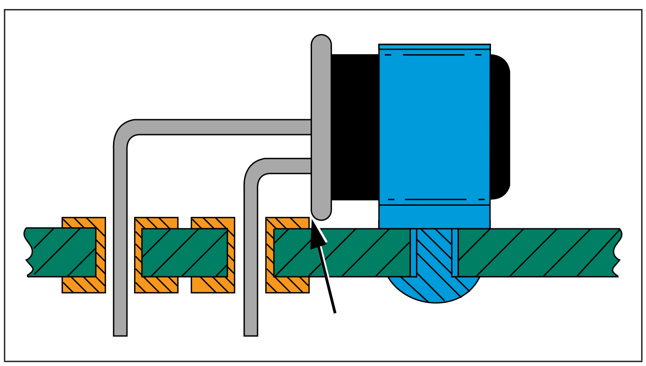

Figure 4-36

Defect - Class 1,2,3

- Spacing between land and uninsulated component body is less than minimum electrical clearance.

4.4.1 Component Mounting – Mounting Clips (cont.)

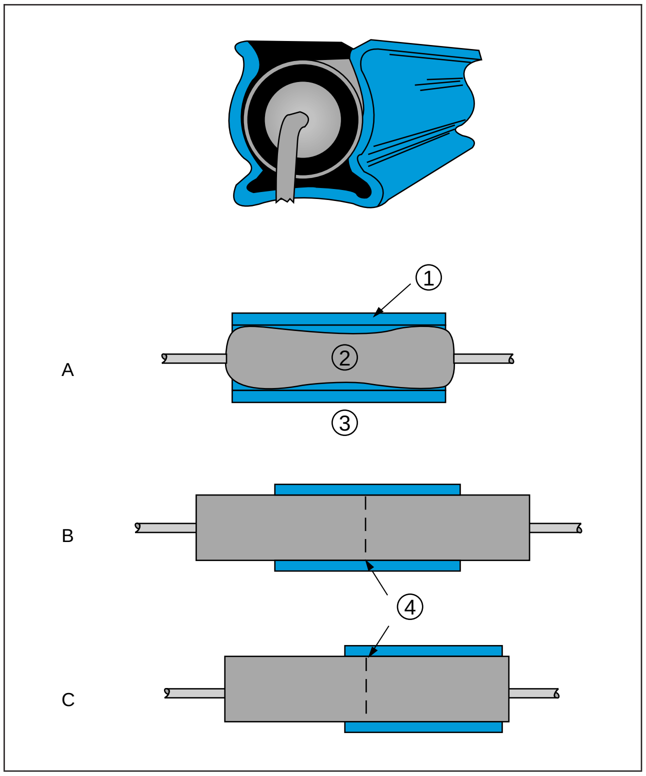

Figure 4-37

1. **Clip**
2. **Nonsymmetrical body**
3. **Top view**
4. **Center of gravity**

Acceptable - Class 1,2,3

A. The clip makes contact with the component sides on both ends of the component.
B. The component is mounted with the center of gravity within the confines of the clip.
C. The end of the component is flush with or extends beyond the end of the clip. Center of component is in the confines of the clip.

4.4.2 Component Mounting – Adhesive Bonding – Non-Elevated Components

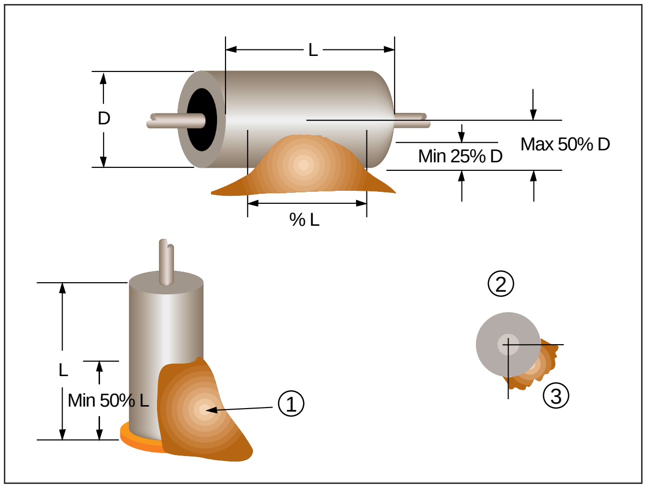

Figure 4-38
1. Adhesive
2. Top view
3. 25% Circumference

Acceptable - Class 1,2,3

- On a horizontally mounted component the adhesive adheres to component for at least 50% of its length (L), and 25% of its diameter, (D), on one side. The build up of adhesive does not exceed 50% of the component diameter. Adhesion to the mounting surface is evident. The adhesive is approximately centered on the body.
- On a vertically mounted component the adhesive adheres to the component for at least 50% of its length, (L), and 25% of its circumference. Adhesion to the mounting surface is evident.
- On multiple vertically mounted components the adhesive adheres to each component for at least 50% of its length, (L), and the adhesion is continuous between components. Adhesion to the mounting surface is evident. The adhesive also adheres to each component for a minimum 25% of its circumference.

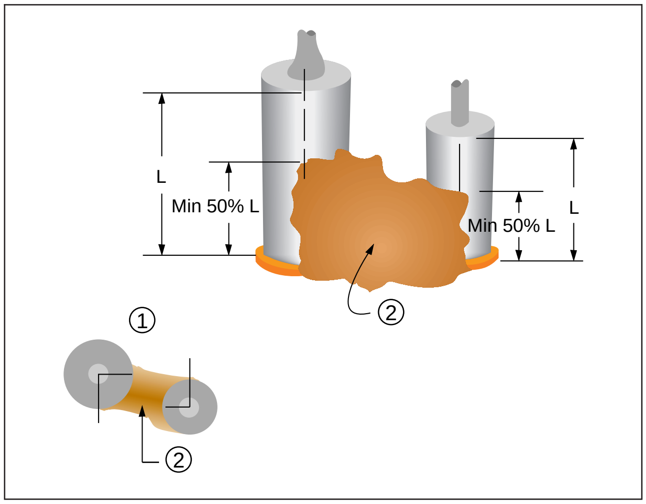

Figure 4-39
1. Top view
2. Adhesive

4.4.2 Component Mounting – Adhesive Bonding – Non-Elevated Components (cont.)

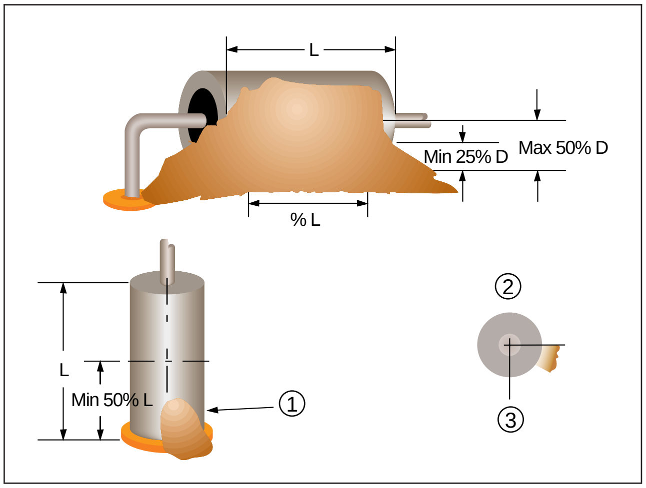

Figure 4-40
1. <50% length (L)
2. Top view
3. <25% circumference

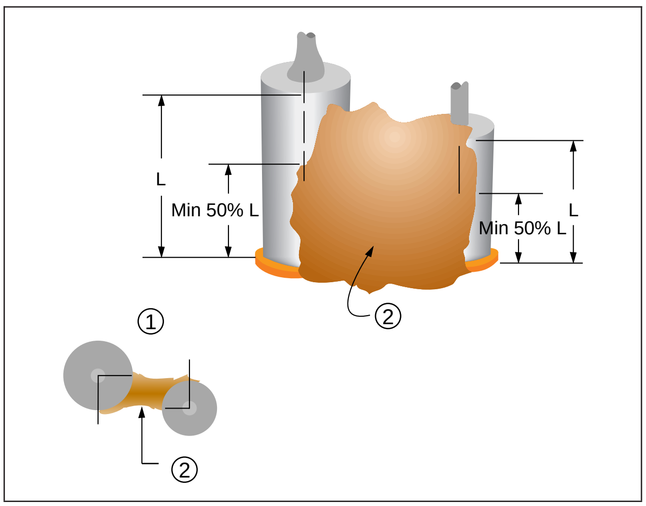

Figure 4-41
1. Top view
2. Adhesive

Acceptable - Class 1
Process Indicator - Class 2,3

- Adhesive in excess of 50% diameter of horizontally mounted components.

Defect - Class 1,2,3

- Less than 25% of the circumference, or equivalent amount of board surface is wetted and adhered to by the adhesive.
- Uninsulated metallic case components bonded over conductive patterns.
- Adhesive on areas to be soldered preventing compliance to Table 6-2.
- On a horizontally mounted component, adhesive adheres to less than 25% of component diameter.
- On a vertically mounted component, adhesive adheres to less than 50% of the component length.

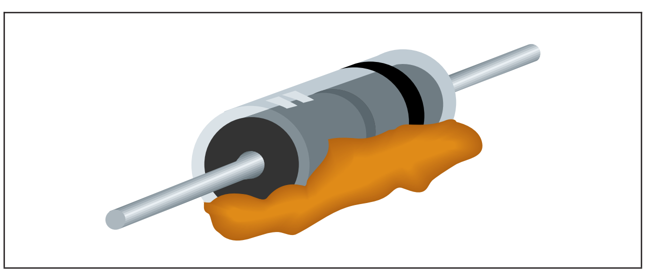

Figure 4-42

Acceptable - Class 1,2,3

- Glass bodied components sleeved prior to adhesive attachment.

Defect - Class 1,2,3

- Rigid adhesive contacts an unsleeved area of glass body component.

4.4.3 Component Mounting – Adhesive Bonding – Elevated Components

This applies in particular to encapsulated or potted transformers and/or coils which are not mounted flush to the board.

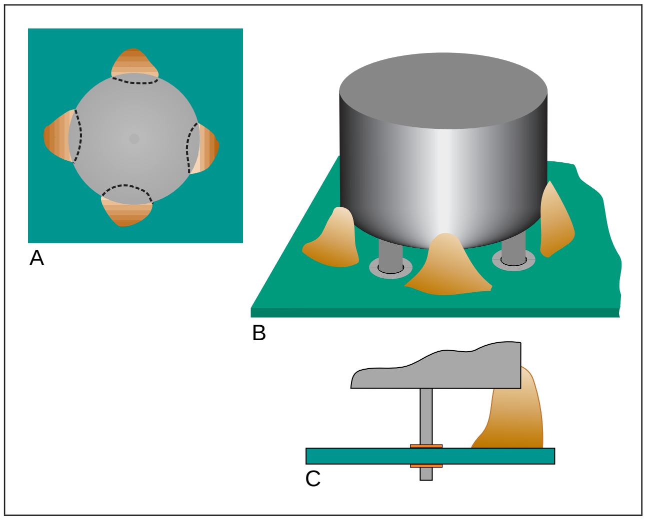

Figure 4-43

Acceptable - Class 1,2,3

A. Bonding requirements should be specified in engineering documents, but as a minimum, components weighing 7g or more per lead are bonded to mounting surface in at least four places evenly spaced around component when no mechanical support is used.
B. At least 20% of the total periphery of the component is bonded.
C. Bonding material firmly adheres to both the bottom and sides of the component and to the printed wiring board.

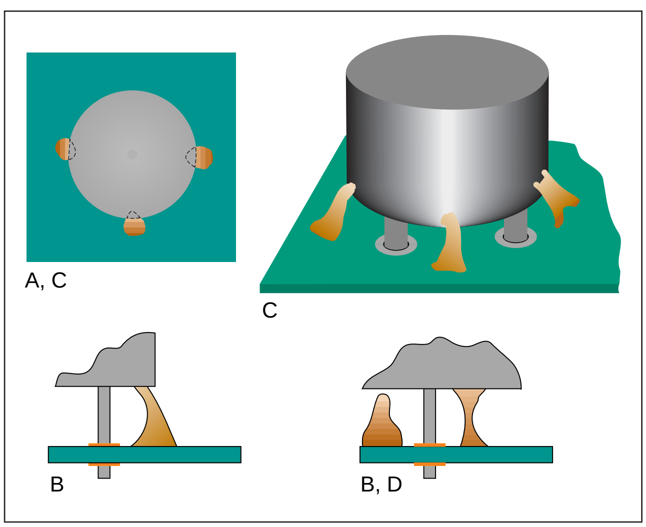

Figure 4-44

Defect - Class 1,2,3

A. Bonding requirements are less than specified in engineering documents and/or components weighing 7g or more per lead have less than four bonding spots.
B. Any bonding spots failing to wet and show evidence of adhesion to both the bottom and side of the component and the mounting surface.
C. Less than 20% of the total periphery of the component is bonded.
D. The bonding material forms too thin a column to provide good support.

4.4.4 Component Mounting – Wire Hold Down

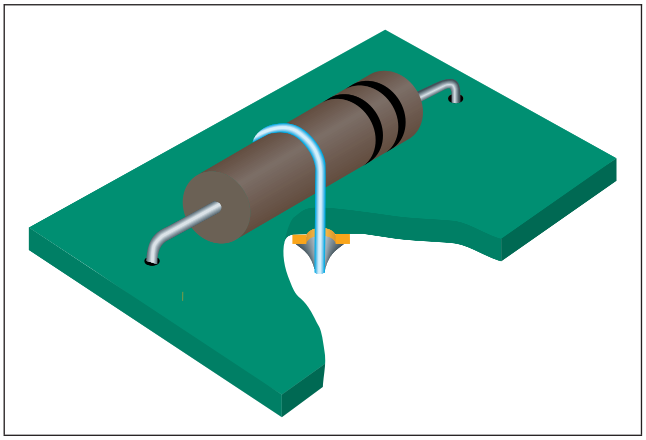

Figure 4-45

Acceptable - Class 1,2,3

- Component is held firmly against the mounting surface.
- There is no damage to the component body or insulation from the securing wire.
- Metal wire does not violate minimum electrical clearance.

4.4.5 Component Mounting – Cable Ties, Tie Wraps, Spot Ties

Note: Do not subject wax impregnated lacing tape to cleaning solvents. Beeswax is unacceptable for Class 3.

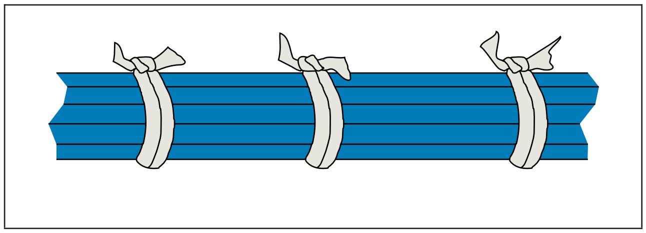

Figure 4-46

Target - Class 1,2,3

- Spot ties are neat and tight, and spaced to keep the wires secured in a tight neat bundle.

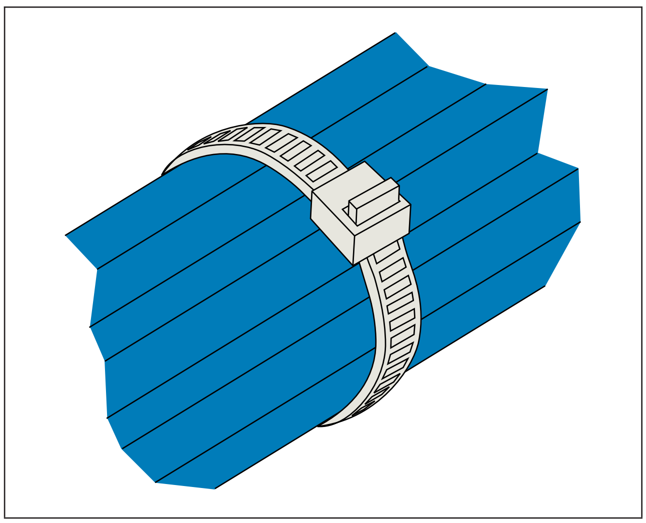

Figure 4-47

Acceptable - Class 1,2,3

- The end of the tie wrap is:
  - A maximum of 0.75 mm [0.0295 in].
  - Cut reasonably square to the face of the wrap.
- The tie wrap is tight.
- The wires are secured in the wire bundle.

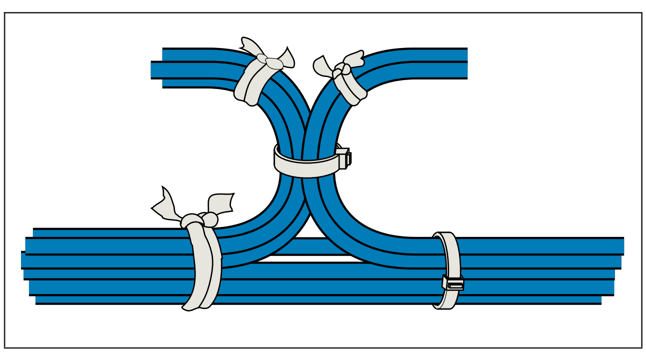

Figure 4-48

Acceptable - Class 1,2,3

- Lacing or tie wraps are placed on both sides of a wire breakout.
- Spot tie wraps are neat and tight.
- The wires are secured in the wire bundle.

4.4.5 Component Mounting – Cable Ties, Tie Wraps, Spot Ties (cont.)

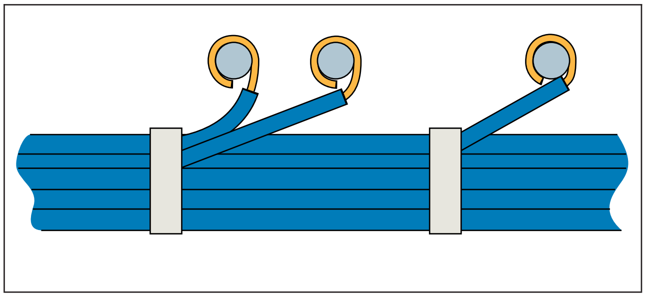

Figure 4-49

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The wire is under stress at the wrap.

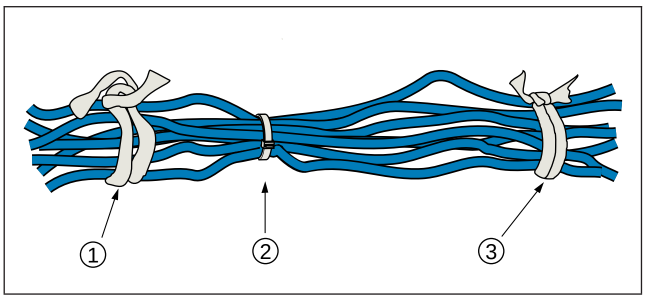

Figure 4-50
1. Loose knot/tie
2. Tie wrap is too tight. Lacing or tie wrap cuts into the insulation.
3. Loose bundle

Defect - Class 1,2,3

- Spot tie wrap or knot is loose.
- Spot tie wrap cuts into the insulation.
- Wire bundle is loose.

4.4.5 Component Mounting – Cable Ties, Tie Wraps, Spot Ties (cont.)

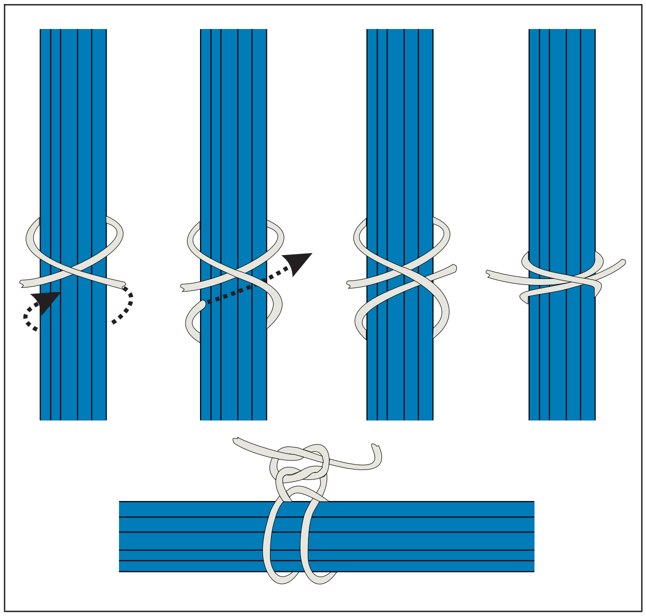

Figure 4-51

Acceptable - Class 1,2,3

- Example of clove-hitch tie method; square knot used to preclude the tie from loosening.
- Other knots used i.e., surgeons knot etc., to secure the clove hitch from loosening must be a type that will prevent loosening in the intended service environment.

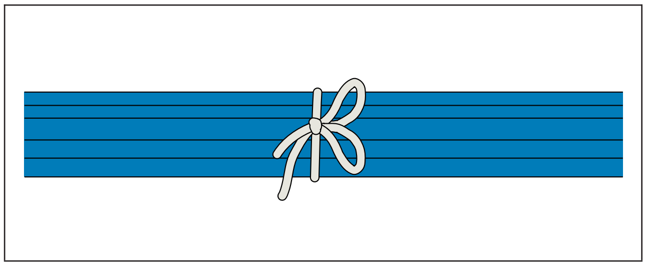

Figure 4-52

Defect - Class 1,2,3

- Cable tied with a bow-knot. This tie may eventually loosen.

4.4.6 Component Mounting – Lacing

Lacing differs from cable ties in that it is a continuous lace. Lacing is spaced at a closer spacing than cable ties. Other criteria for cable ties apply to lacing also.

Note: Do not subject wax impregnated lacing tape to cleaning solvents. Beeswax is unacceptable for Class 3.

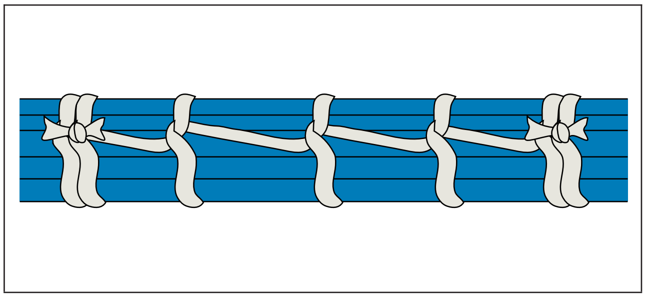

Figure 4-53

Acceptable - Class 1,2,3

- Lacing begins and ends with a knot.
- Lacing is tight and wires are kept secure in a neat bundle.

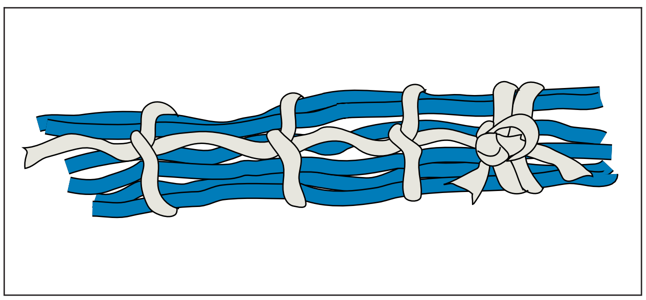

Figure 4-54

Defect - Class 1,2,3

- Lacing is loose, leaving wires loose in the wire bundle.
- Lacing is too tight, cutting into insulation (not shown).

4.4.7 Component Mounting – Wire Dress for Terminations to Connectors Without Strain/Stress Relief

Wires connecting to multi-contact connectors have slack adjusted to preclude stress of individual wires.

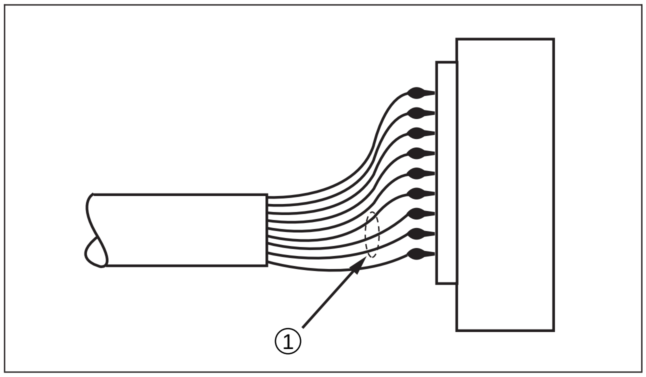

Figure 4-55
1. Lead dress is more critical on these wires

Acceptable - Class 1,2,3

- Wires exiting connector are positioned as they would be at installation.
- All wires are dressed with even bends to prevent stress at contact connections.
- Shortest wires are in direct line with center axis of cable.

Note: The number of contacts with no fanout slack is limited to seven or fewer for round or multiple-rowed rectangular connectors and eight or fewer for dual contact-rowed rectangular connectors.

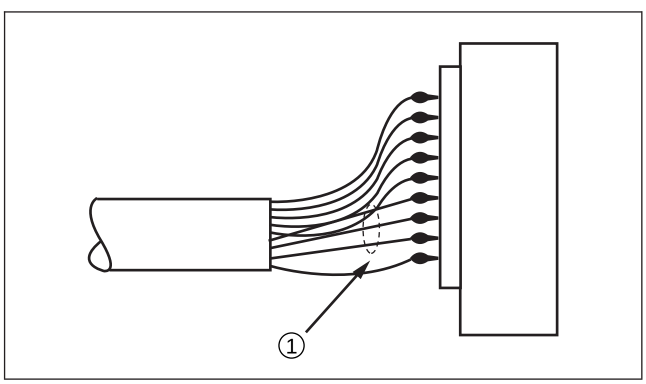

Figure 4-56
1. Leads are stressed

Defect - Class 1

- Wires are separated from the connector.

Defect - Class 2,3

- Slack is inadequate to prevent stress of individual wires.

4.5 Connectors, Handles, Extractors

This section shows some of the many different types of rivet mounted connectors, handles and extractors. These devices need to be visually inspected for cracks and damage.

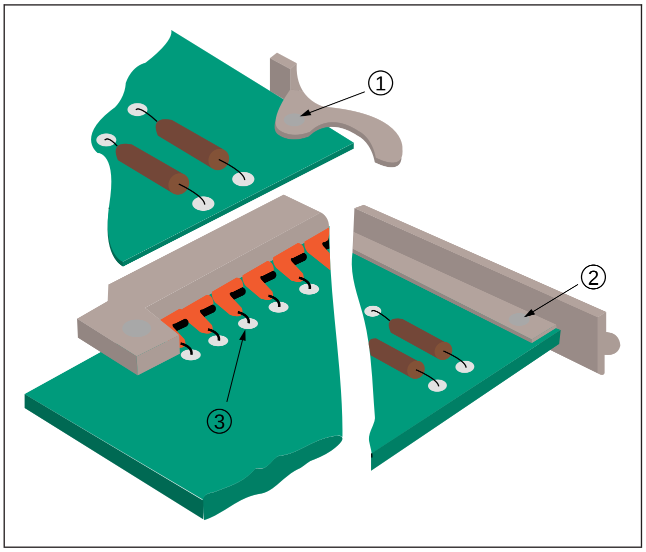

Figure 4-57
1. Extractor
2. Securing hardware
3. Component lead

Target - Class 1,2,3

- No damage to part, printed board or securing hardware (rivets, screws, etc.).

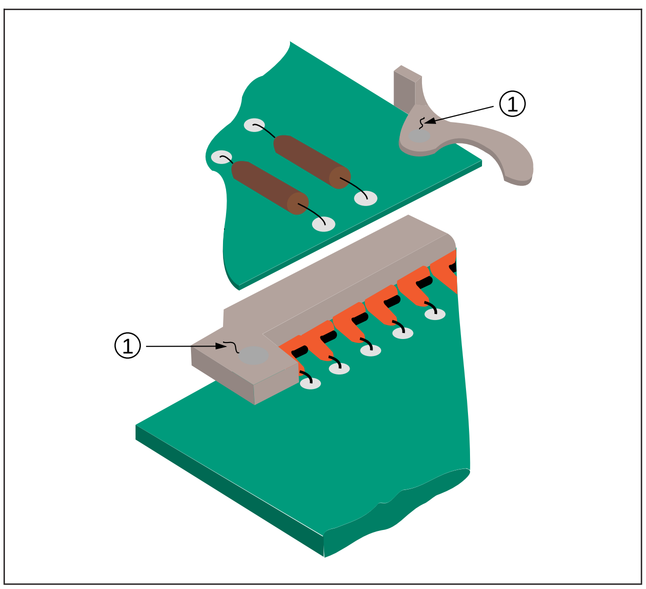

Figure 4-58
1. Crack

Acceptable - Class 1

- Cracks in the mounted part extend no more than 50% of the distance between a mounting hole and a formed edge.

Defect - Class 1

- Cracks in the mounted part extend more than 50% of the distance between a mounting hole and a formed edge.

Defect - Class 2,3

- Cracks in mounting part.

Defect - Class 1,2,3

- Crack connects a mounting hole to an edge.
- Damage/stress to connector lead pins.

4.6 Heatsink

This section illustrates various types of heatsink mounting. Bonding with thermally conductive adhesives may be specified in place of hardware.

Visual inspection needs to include hardware security, component or hardware damage, and correct sequence of assembly.

The following concerns with heatsinks must be addressed:

- Does the component have good contact with the heatsink?
- Is the hardware securing the component to the heatsink?
- Are the component and heatsink flat and parallel to each other?
- Is the thermal compound/insulator (mica, silicone grease, plastic film, etc.) applied properly?

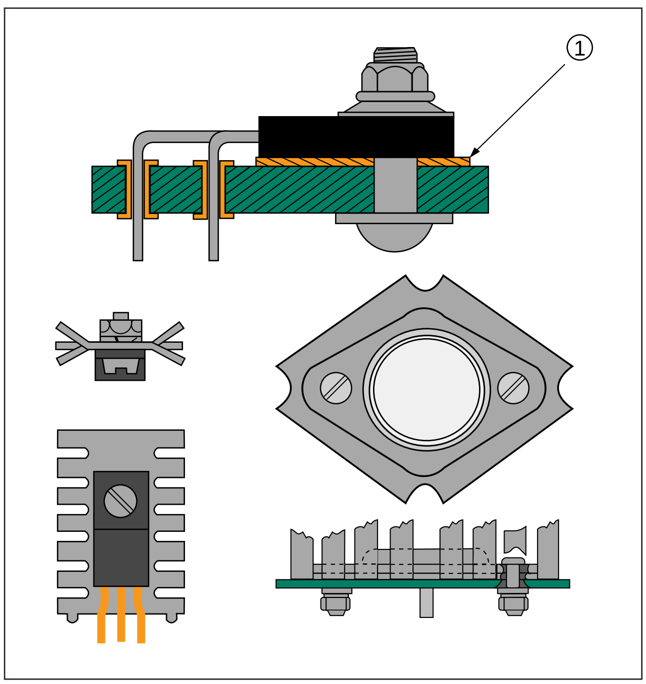

Figure 4-59
1. Heatsink

Acceptable - Class 1,2,3

- Heatsinks are mounted flush.
- No damage or stress on components.

4.6 Heatsink (cont.)

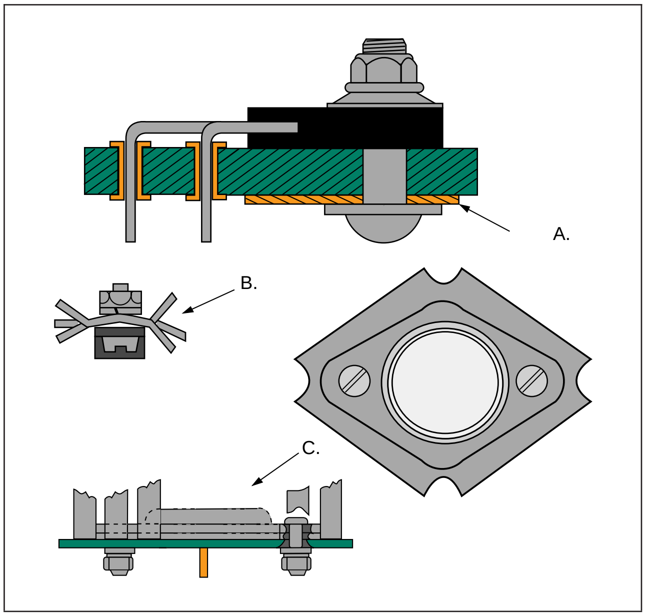

Figure 4-60

Defect - Class 1,2,3

A. Heatsink on wrong side of board.
B. Bent heatsink.
C. Missing fins on heatsink.

4.6.1 Heatsink – Insulators and Thermal Compounds

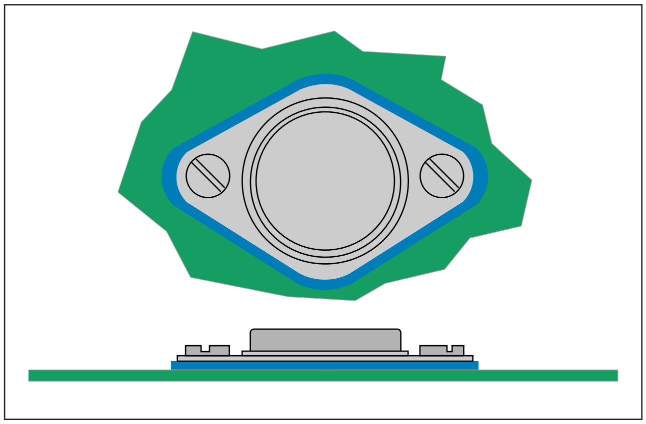

Figure 4-61

Target - Class 1,2,3

- Uniform border of mica, plastic film or thermal compound showing around edges of component.

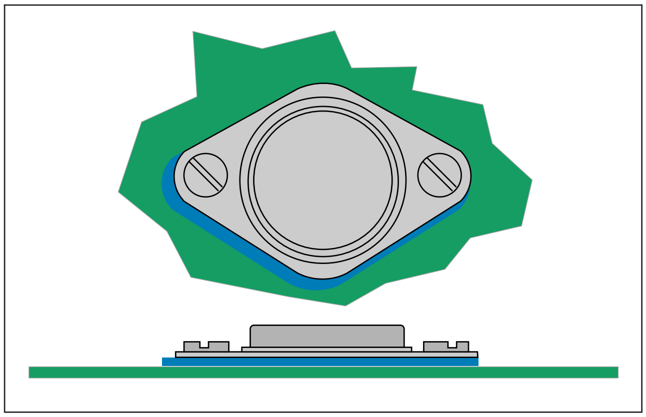

Figure 4-62

Acceptable - Class 1,2,3

- Nonuniform but evidence of mica, plastic film or thermal compound showing around edges of component.

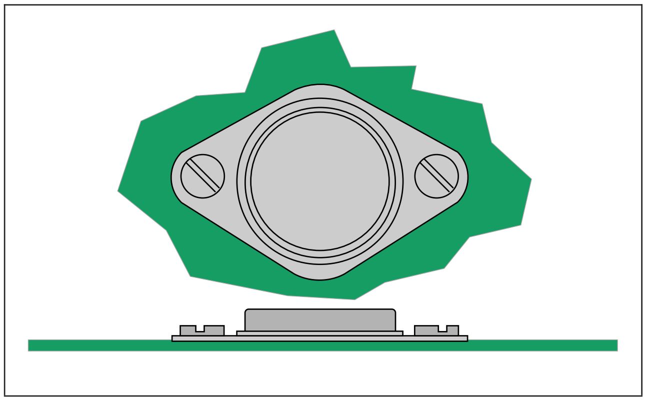

Figure 4-63

Defect - Class 1,2,3

- No evidence of insulating materials, or thermal compound (if required).

4.6.2 Heatsink – Contact

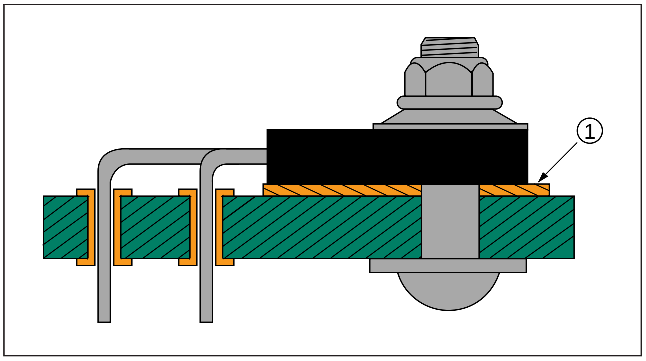

Figure 4-64
1. Heat sink

Target - Class 1,2,3

- Component and heatsink are in full contact with the mounting surface.
- Hardware meets specified attachment requirements.

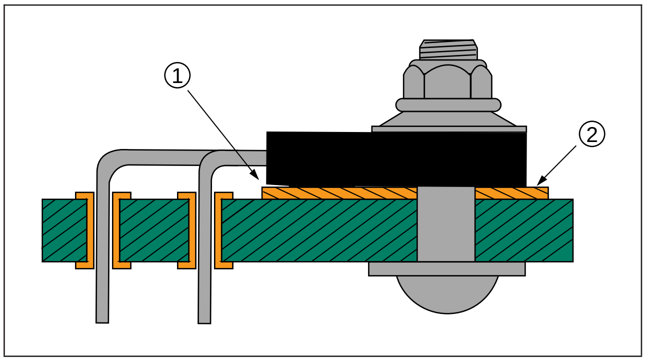

Figure 4-65
1. Gap
2. Heat sink

Acceptable - Class 1,2,3

- Component not flush.
- Minimum 75% contact with mounting surface.
- Hardware meets mounting torque requirements if specified.

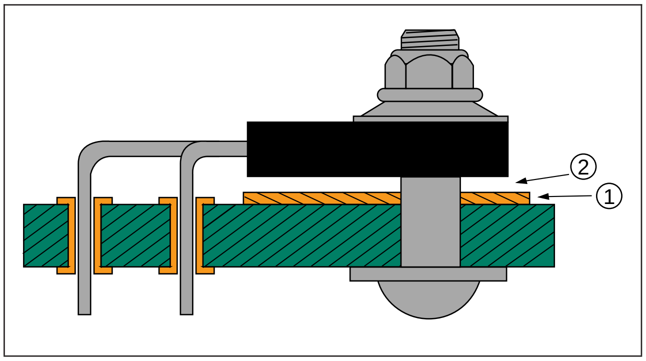

Figure 4-66
1. Heat sink
2. Gap

Defect - Class 1,2,3

- Component is not in contact with mounting surface.
- Hardware is loose and can be moved.

4.7 Terminals – Edge Clip

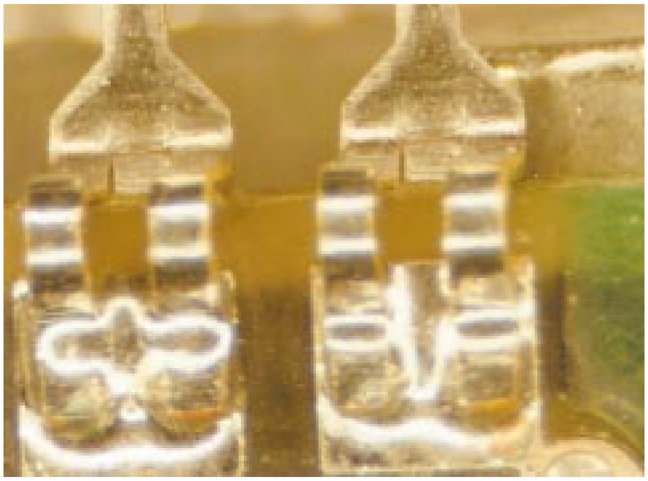

Figure 4-67

Target - Class 1,2,3

• Clip is centered on land with no side overhang.

Figure 4-68

Acceptable - Class 1,2,3

• Clip has 25% maximum overhang off land.

• Overhang does not reduce spacing below minimum electrical clearance.

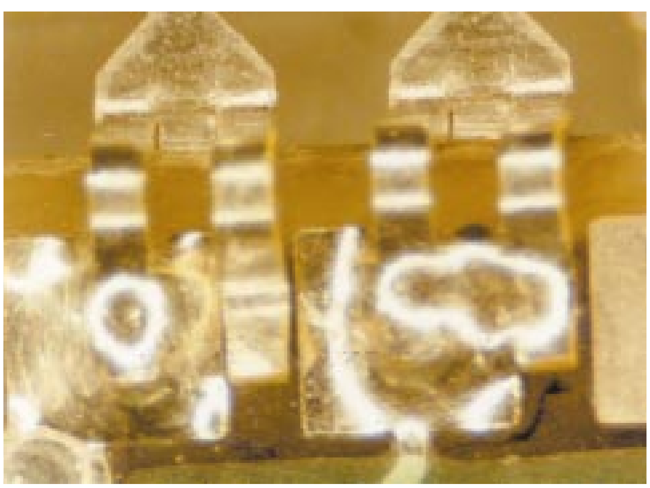

Figure 4-69

Defect - Class 1,2,3

• Clip exceeds 25% overhang off land.

• Clip overhangs land, reducing the spacing below minimum electrical clearance.

4.8 Connector Pins

This section covers two types of pin installations; edge connector pins and connector pins. Installation of these devices is usually done with automated equipment. Visual inspection of this mechanical operation includes: correct pins, damaged pins, bent and broken pins, damaged spring contacts and damage to the substrate or conductive pattern.

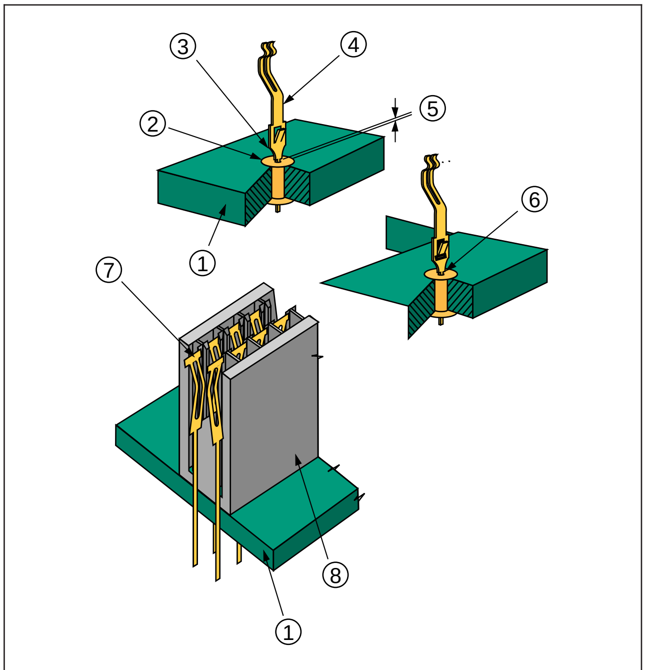

Figure 4-70
1. Backplane
2. Land
3. Shoulder
4. Contact
5. Gap
6. No land damage
7. No discernible damage
8. Insulator

Acceptable - Class 1,2,3

- Contact is not broken or twisted. Gap is within specified tolerance.
- No land damage.
- Contact is contained within the insulator.

Note: In order to provide allowance for an extraction tool, the gap between the contact shoulder and the land needs to be adequate for each manufacturer's repair tooling.

4.8.1 Connector Pins – Edge Connector Pins

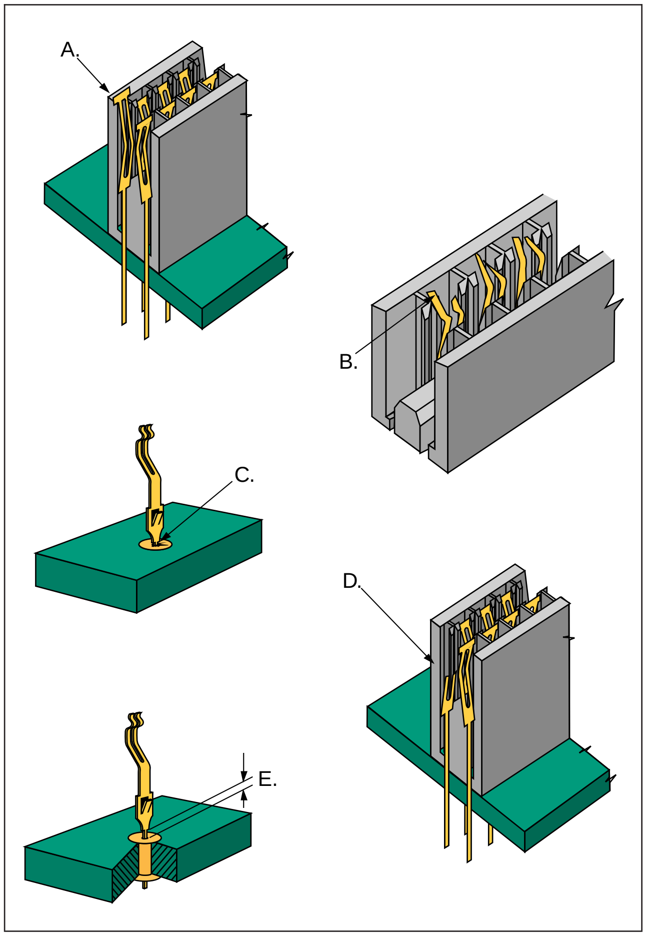

Figure 4-71

Defect - Class 1,2,3

A. Contact is above insulator.
B. Contacts are twisted or otherwise deformed.
C. Land is damaged.
D. Contact is broken.
E. Gap between contact shoulder and land is greater than specified.

4.8.2 Connector Pins – Press-Fit Pins

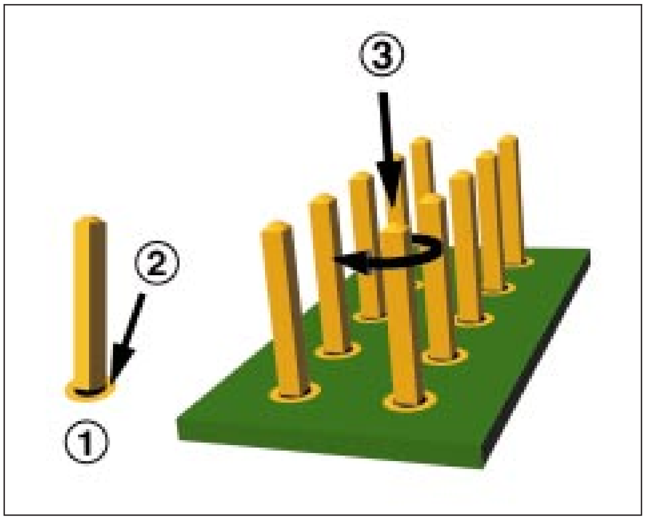

Figure 4-72
1. No discernible damage
2. Land
3. No discernible twist

Target - Class 1,2,3

- Pins are straight, not twisted and properly seated.
- No discernible damage.

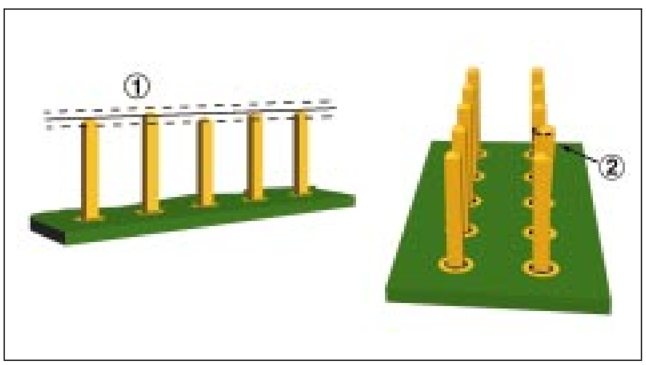

Figure 4-73
1. Pin height tolerance
2. Less than 50% pin thickness

Acceptable - Class 1,2,3

- Pins are slightly bent off center by 50% pin thickness or less.
- Pin height varies within tolerance.

Note: Nominal height tolerance is per pin connector or master drawing specification. The connector pins and mating connector must have a good electrical contact.

4.8.2 Connector Pins – Press-Fit Pins (cont.)

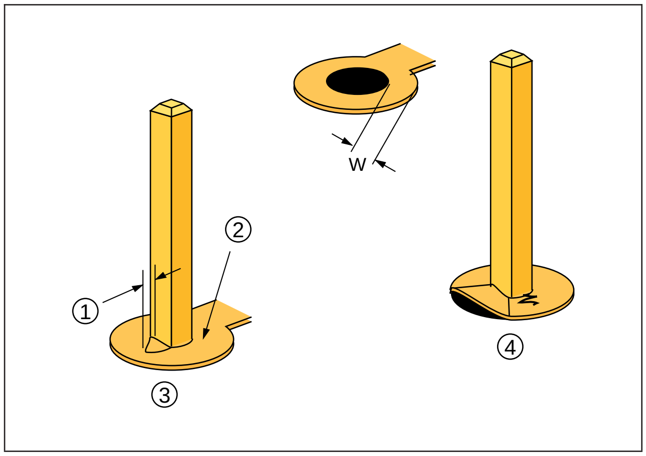

Figure 4-74

1. **Land lifted 75% of annular ring or less**
2. **Land with conductor**
3. **Land not fractured**
4. **Land lifted, fractured but firmly attached land without conductor (nonfunctional)**

Acceptable - Class 1,2

- Less than or equal to 75% of the width (W) of the annular ring is lifted.
- Damaged nonfunctional lands for single and double-sided boards are acceptable if firmly attached to board in unlifted areas.

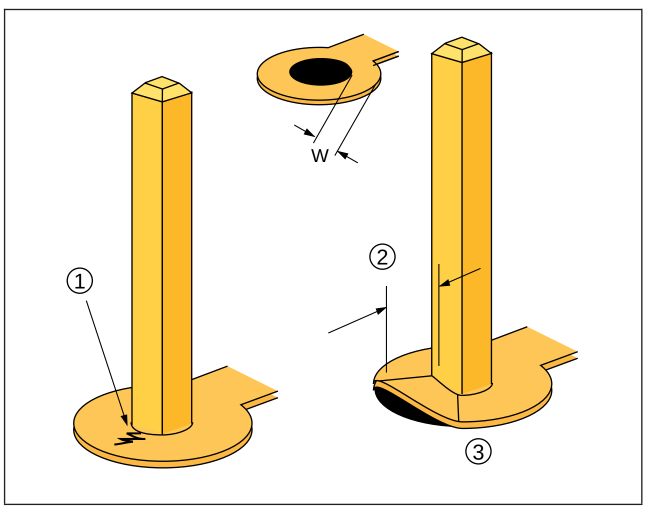

Figure 4-75

1. **Land fractured**
2. **Functional land lifted greater than 75% of annular ring**
3. **Land lifted**

Defect - Class 1,2

- Any functional annular ring which is lifted more than 75% of the width (W).

Defect - Class 3

- Any lifted or fractured annular rings with machine-inserted pins.

Note: For additional information see 10.7.2 Conductor/Land Damage - Lifted Pads/Lands.

4.8.2 Connector Pins – Press-Fit Pins (cont.)

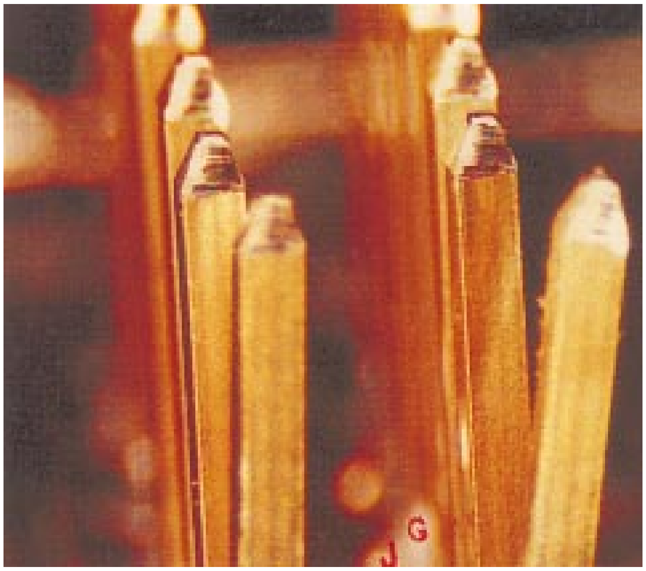

Figure 4-76

Defect - Class 1,2,3

- Pin is bent out of alignment. (Pin is bent off center greater than 50% pin thickness.)

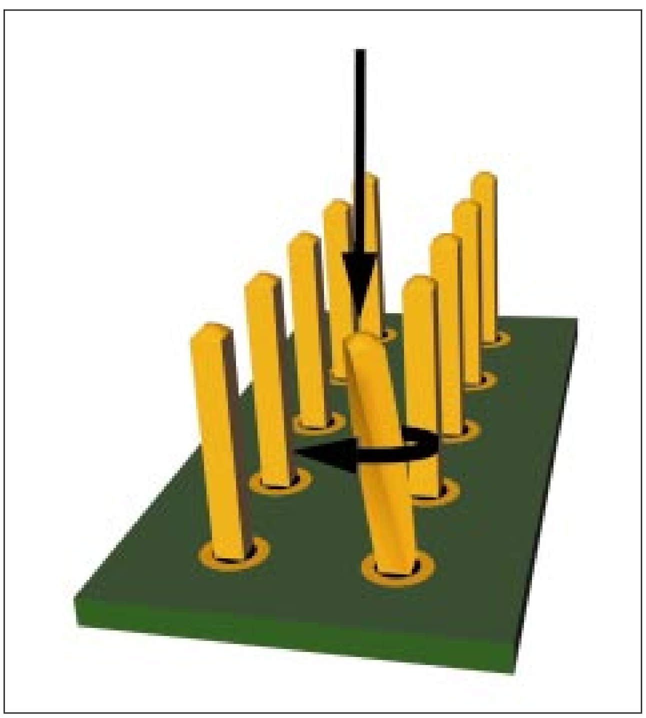

Figure 4-77

Defect - Class 1,2,3

- Pin visibly twisted.

4.8.2 Connector Pins – Press-Fit Pins (cont.)

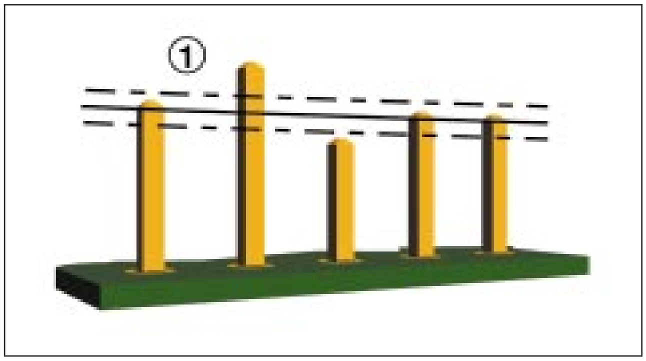

Figure 4-78

Defect - Class 1,2,3

- Pin height is out of tolerance as to specification.

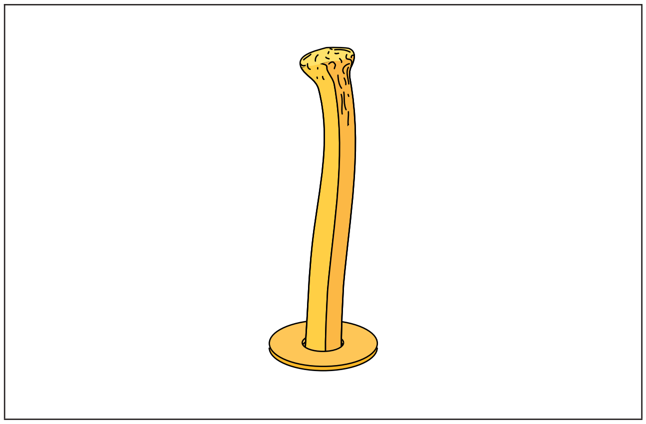

Figure 4-79

Defect - Class 1,2,3

- Damaged pin as a result of handling or insertion.
  - Mushroomed
  - Bent

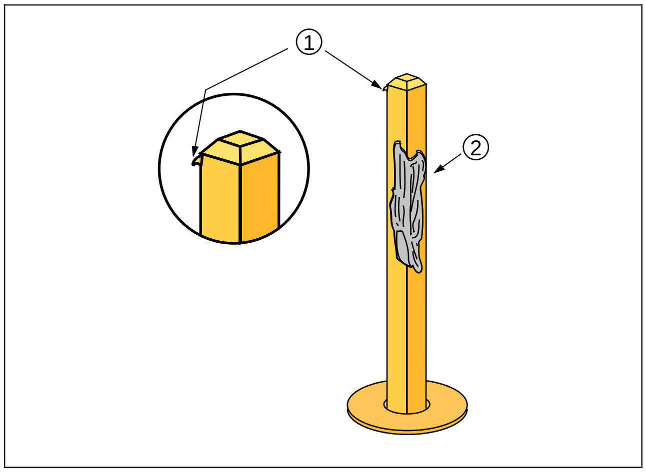

Figure 4-80
1. Burr
2. Plating missing

Defect - Class 1,2,3

- Damaged pin. (Exposed basis metal).

Defect - Class 2,3

- Burr

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Component Installation Location/Orientation

This section covers acceptability requirements for the installation, location, and orientation of components and wires mounted onto printed boards, including both direct mounting to lands and mounting to standoff terminals.

Criteria is given for only the actual mounting or placement of components or wires on electronic assemblies and to standoff terminals. Solder is mentioned where it is an integral part of the placement dimensions, but only as related to those dimensions. The condition and amount of solder for connections is covered in Section 6.

The criteria in this section are grouped together in seven main subsections. Not all combinations of wire/lead types and terminal types can possibly be covered explicitly, so criteria is typically stated in general terms to apply to all similar combinations. For example, a resistor lead and a multistrand jumper wire connected to turret terminals have the same wrap and placement requirements, but only the multistranded wire could be subject to birdcaging.

The sequence of topics listed below follows the general sequence of steps for inspection.

Inspection usually starts with a general overall view of the electronic assembly, then follows each component/wire to its connection, concentrating on the lead into the connection, the connection and the tail end of the lead/wire leaving the connection. The wire/lead protrusion step for all lands should be saved for last so that the board can be flipped over and all connections checked together.

This section addresses the following subjects:

5.1 Orientation

5.1.1 Orientation – Horizontal

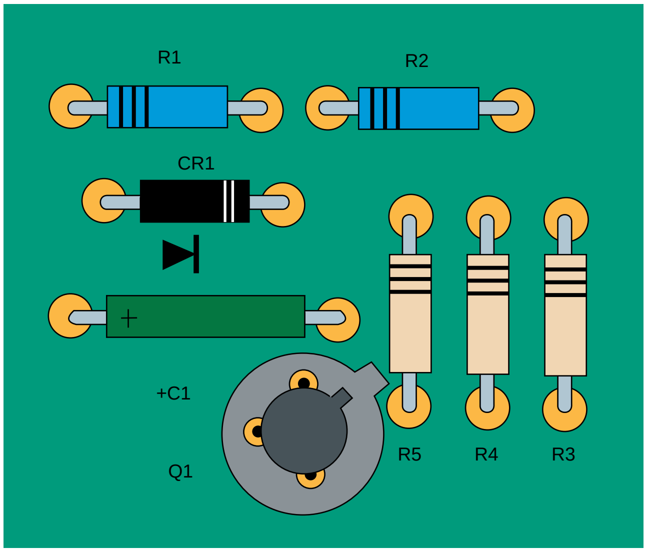

Figure 5-1

Target - Class 1,2,3

- Components are centered between their lands.
- Component markings are discernible.
- Nonpolarized components are oriented so that markings all read the same way (left-to-right or top-to-bottom).

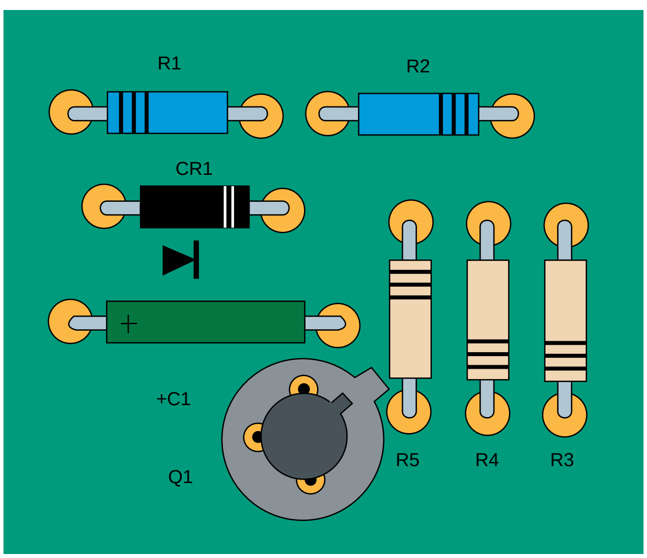

Figure 5-2

Acceptable - Class 1,2,3

- Polarized and multilead components are oriented correctly.
- When hand formed and hand-inserted, polarization symbols are discernible.
- All components are as specified and terminate to correct lands.
- Nonpolarized components do not need to be oriented so that markings all read the same way (left-to-right or top-to-bottom).

5.1.1 Orientation – Horizontal (cont.)

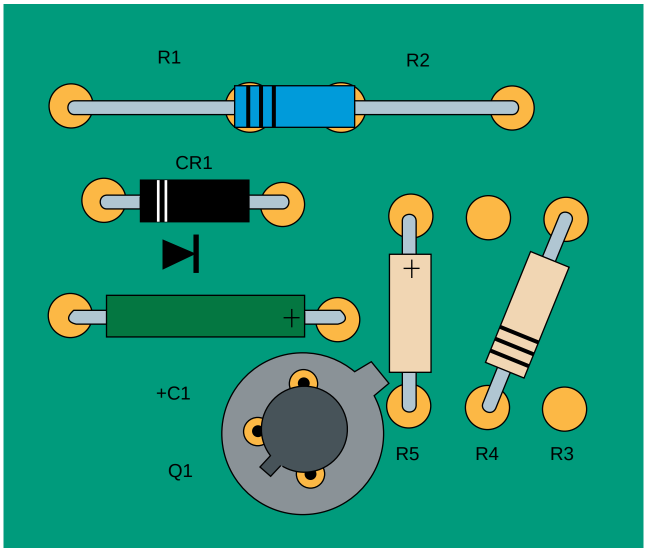

Figure 5-3

Defect - Class 1,2,3

- Component is not as specified (wrong part).
- Component not mounted in correct holes.
- Polarized component mounted backwards.
- Multileaded component not oriented correctly.

5.1.2 Orientation – Vertical

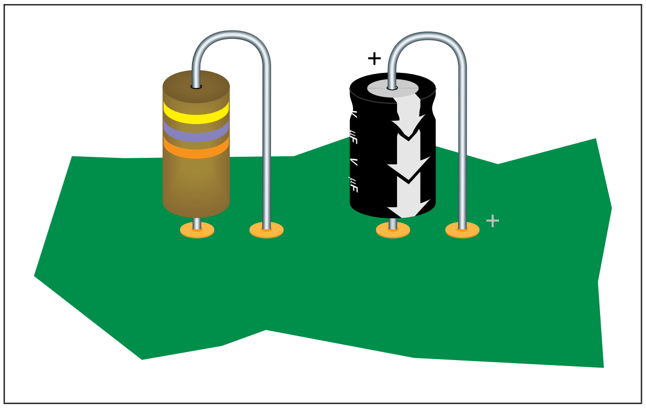

Figure 5-4

Target - Class 1,2,3

- Nonpolarized component markings read from the top down.
- Polarized markings are located on top.

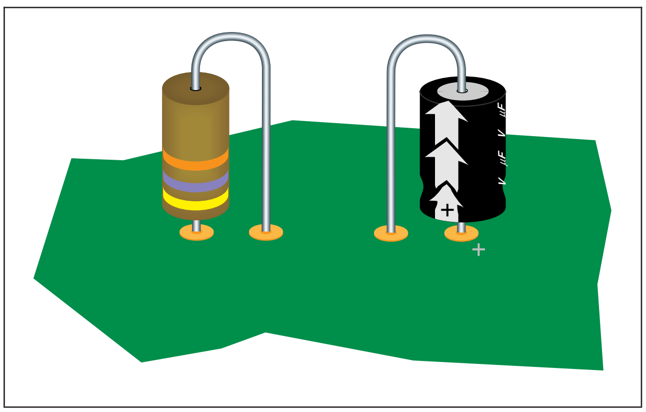

Figure 5-5

Acceptable - Class 1,2,3

- Polarized part is mounted with a long ground lead.
- Polarized marking hidden.
- Nonpolarized component markings read from bottom to top.

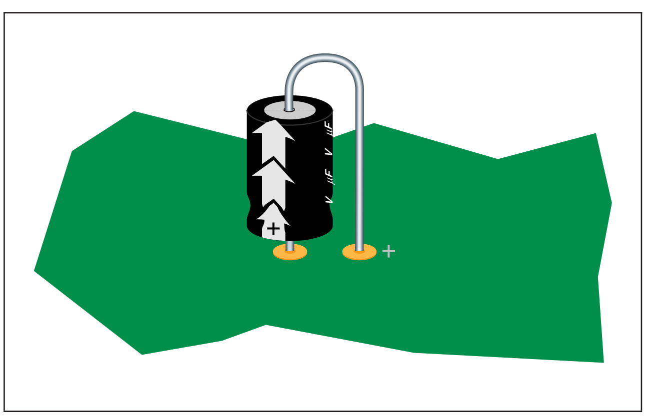

Figure 5-6

Defect - Class 1,2,3

- Polarized component is mounted backwards.

5.2 Mounting

5.2.1 Mounting – Horizontal – Axial Leaded – Supported Holes

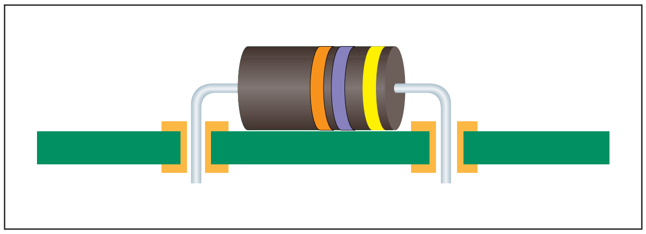

Figure 5-7

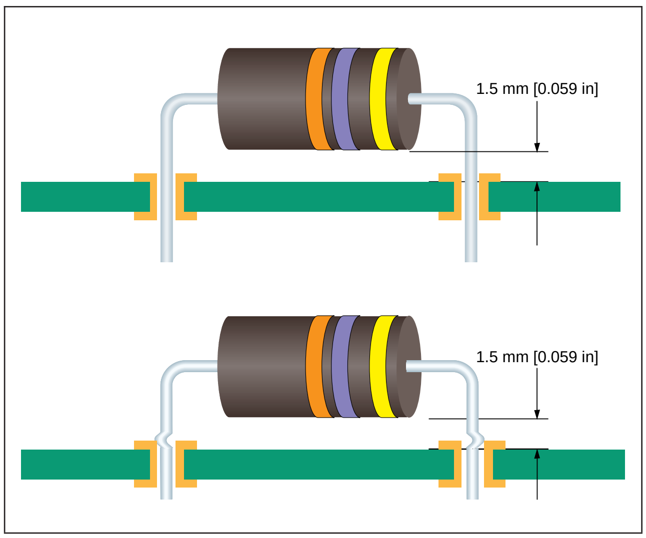

Figure 5-8

Target - Class 1,2,3

- The entire body length of the component is in contact with the board surface.
- Components required to be mounted off the board are at least 1.5 mm [0.059 in] from the board surface; e.g., high heat dissipating.

5.2.1 Mounting – Horizontal – Axial Leaded – Supported Holes (cont.)

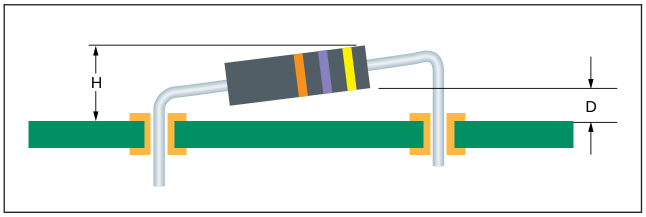

Figure 5-9

Acceptable - Class 1,2

- The maximum space between the component and the board surface does not violate the requirements for lead protrusion (see 5.2.7) or component height (H). ((H) is a user-determined dimension.)

Process Indicator - Class 3

- The farthest distance between the component body and the board (D) is larger than 0.7 mm [0.028 in].

Defect - Class 1,2,3

- Components required to be mounted above the board surface are less than 1.5 mm [0.059 in].

5.2.2 Mounting – Horizontal – Axial Leaded – Unsupported Holes

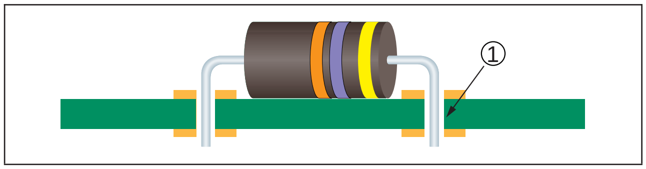

Figure 5-10
1. No Plating in barrel

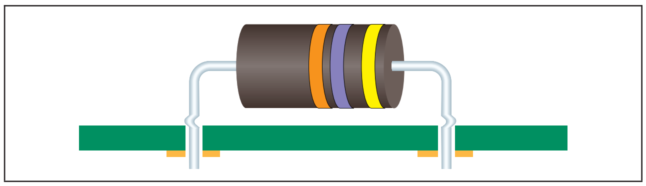

Figure 5-11

Figure 5-12
1. Lead forms

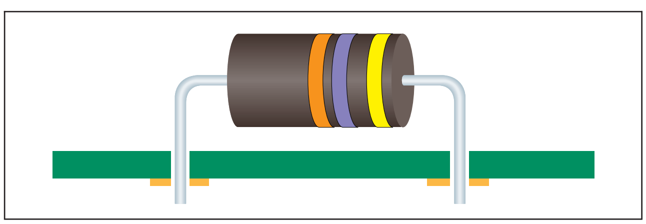

Figure 5-13

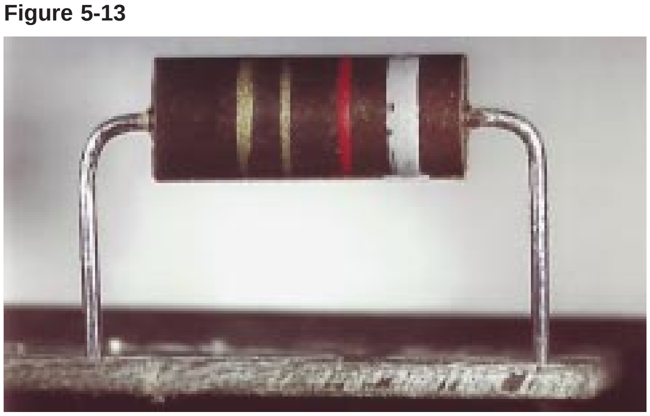

Figure 5-14

Target - Class 1,2,3

- The entire body length of the component is in contact with the board surface.
- Components required to be mounted off the board are at minimum 1.5 mm [0.059 in] from the board surface; e.g., high heat dissipating.
- Components required to be mounted off the board are provided with lead forms at the board surface or other mechanical support to prevent lifting of solder land.

Defect - Class 1,2,3

- Components required to be mounted off the board are not provided with lead forms at the board surface or other mechanical support to prevent lifting of solder land.
- Components required to be mounted above the board surface are less than 1.5 mm [0.059 in].

5.2.3 Mounting – Horizontal – Radial Leaded

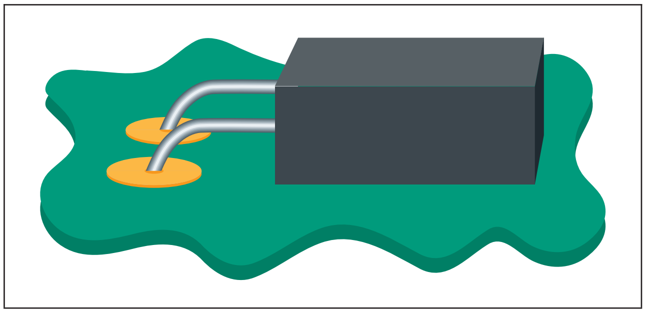

Figure 5-15

Target - Class 1,2,3

- The component body is in flat contact with the board's surface.
- Bonding material is present, if required. See 4.4.

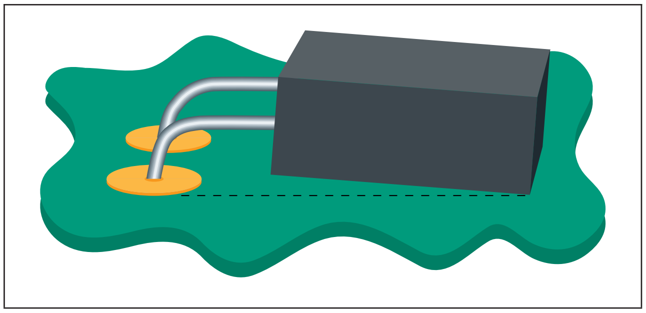

Figure 5-16

Acceptable - Class 1,2,3

- Component in contact with board on at least one side and/or surface.

Note: When documented on an approved assembly drawing, a component may be either side mounted or end mounted. The side or surface of the body, or at least one point of any irregularly configured component (such as certain pocketbook capacitors), needs to be in full contact with the printed board. The body should to be bonded or otherwise retained to the board to prevent damage when vibration and shock forces are applied.

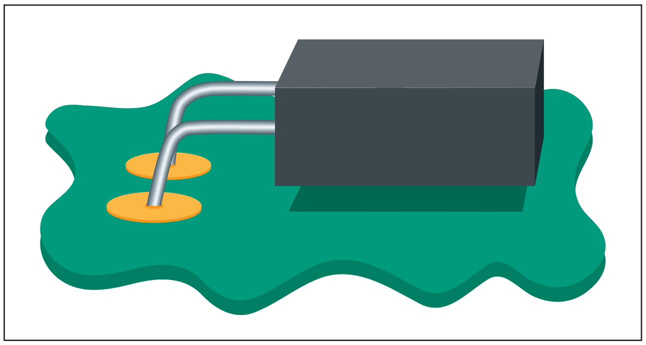

Figure 5-17

Defect - Class 1,2,3

- Unbonded component body not in contact with mounting surface.
- Bonding material not present if required.

5.2.4 Mounting – Vertical – Axial Leaded – Supported Holes

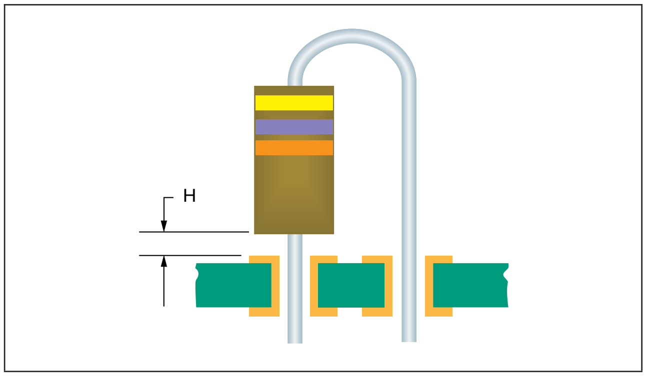

Figure 5-18

Target - Class 1,2,3

- The height of the component body above the land, (H) is 0.4 mm [0.016 in] to 1.5 mm [0.059 in].
- The component body is perpendicular to the board.
- The overall height does not exceed the height specified.

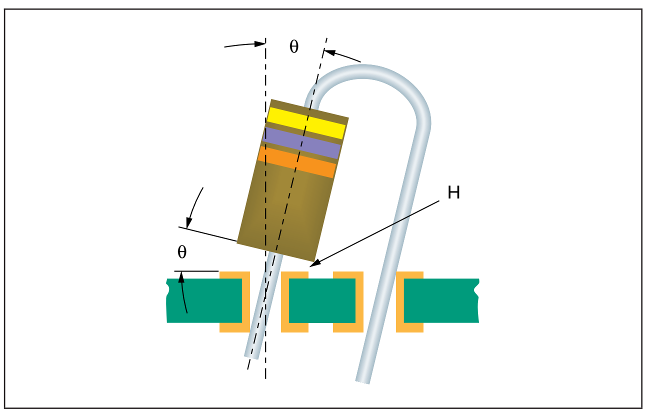

Figure 5-19

Acceptable - Class 1,2,3

- The component height above the board, (H) is not outside the range given in Table 5-1.
- The angle (θ) of the component lead does not cause a violation of minimum electrical clearance.

Table 5-1 Component to Board Height

	Class 1	Class 2	Class 3
H(min)	0.1 mm [0.0039 in]	0.4 mm [0.016 in]	0.4 mm [0.016 in]
H(max)	6 mm [0.24 in]	3 mm [0.12 in]	1.5 mm [0.059 in]

5.2.4 Mounting – Vertical – Axial Leaded – Supported Holes (cont.)

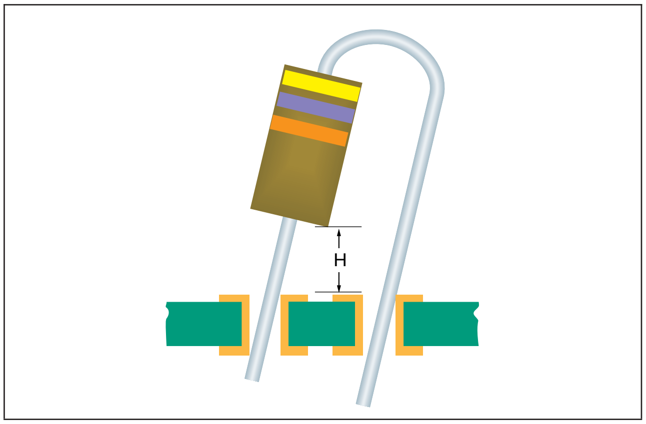

Figure 5-20

Acceptable - Class 1
Process Indicator - Class 2,3

- The component mounting height (H) is greater than the maximum given in Table 5-1.

Defect - Class 1,2,3

- Components violate minimum electrical clearance.

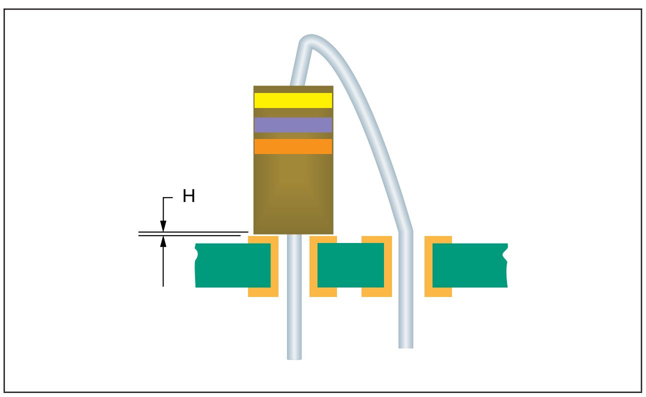

Figure 5-21

Acceptable - Class 1
Process Indicator - Class 2,3

- The component height (H) is less than the minimum given in Table 5-1.

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The inside bend radius does not meet requirements. See Table 5-3.

5.2.5 Mounting – Vertical – Axial Leaded – Unsupported Holes

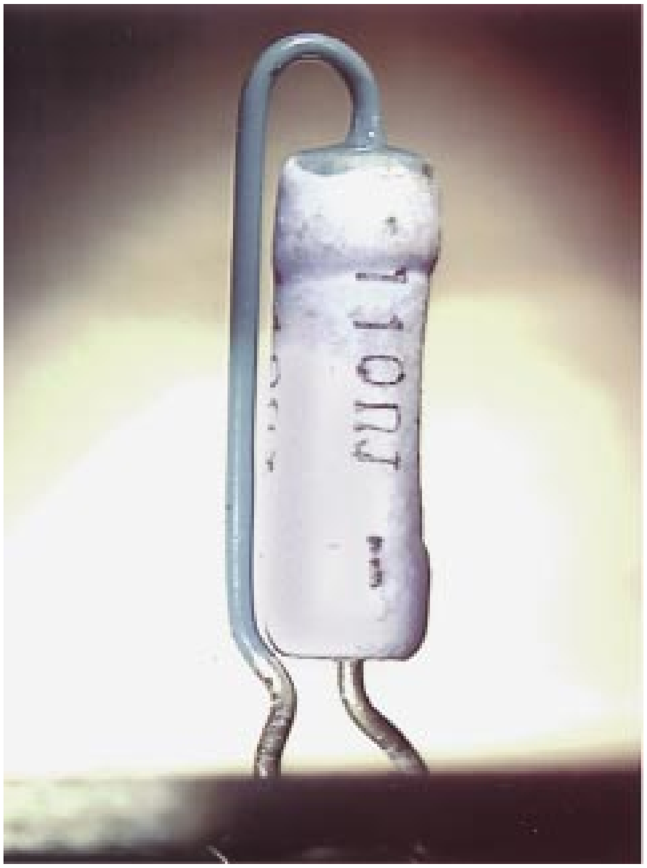

Figure 5-22

Target - Class 1,2,3

• Components that are mounted above the board surface in unsupported holes are provided with lead forms or other mechanical support to prevent lifting of solder land.

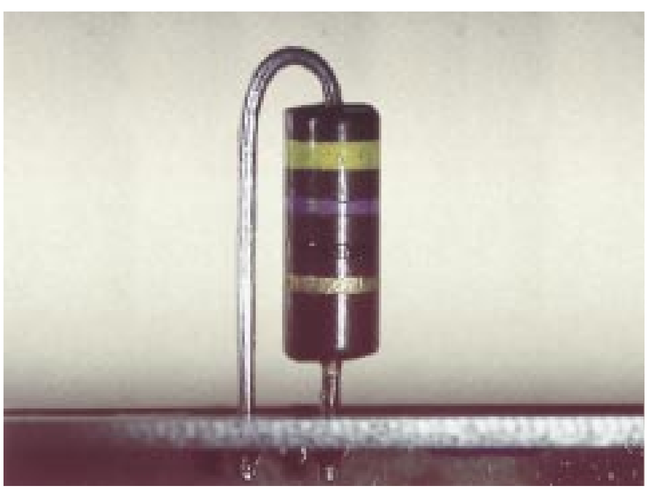

Figure 5-23

Defect - Class 1,2,3

• Components mounted in unsupported holes are mounted without lead form at the board surface.

5.2.6 Mounting – Vertical – Radial Leaded

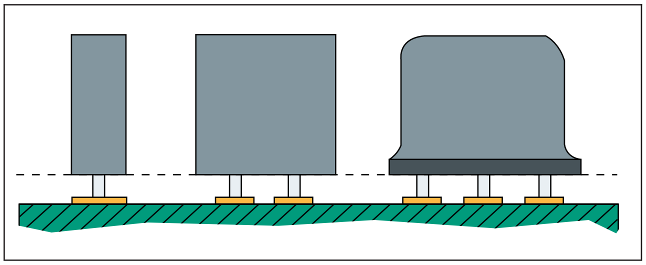

Figure 5-24

Target - Class 1,2,3

- Component is perpendicular and base is parallel to board.
- Space between base of component and board surface is between 0.3 mm [0.012 in] and 2 mm [0.079 in].

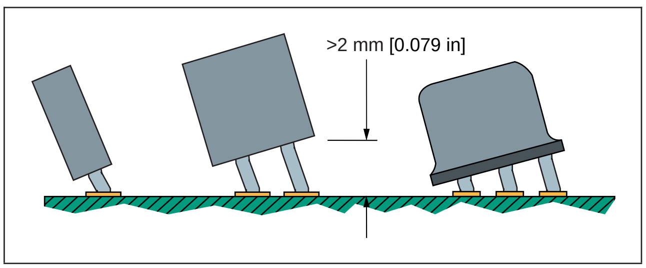

Figure 5-25

Acceptable - Class 1,2,3

- Component tilt does not violate minimum electrical clearance.

Process Indicator - Class 2,3

- Space between component base and board surface is less than 0.3 mm [0.012 in] or more than 2 mm [0.079 in].

Defect - Class 1,2,3

- Violates minimum electrical clearance.

Note: Some components cannot be tilted due to mating requirements with enclosures or panels, for example toggle switches, potentiometers, LCDs, and LEDs.

5.2.6.1 Mounting – Vertical – Radial Leaded – Component Mounting Spacers

Note: Spacers used for mechanical support or to compensate for component weight must be in full contact with both component and board surface.

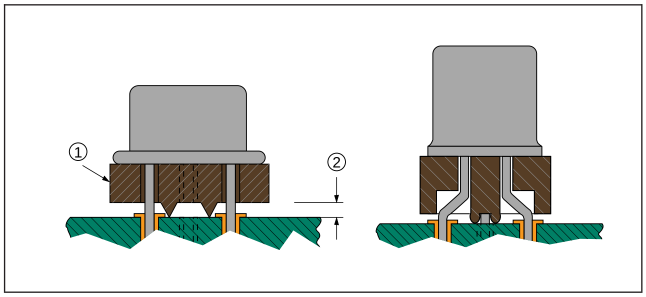

Figure 5-26
1. Spacer
2. Contact

Target - Class 1,2,3

- Spacer is in full contact with both component and board.
- Lead is properly formed.

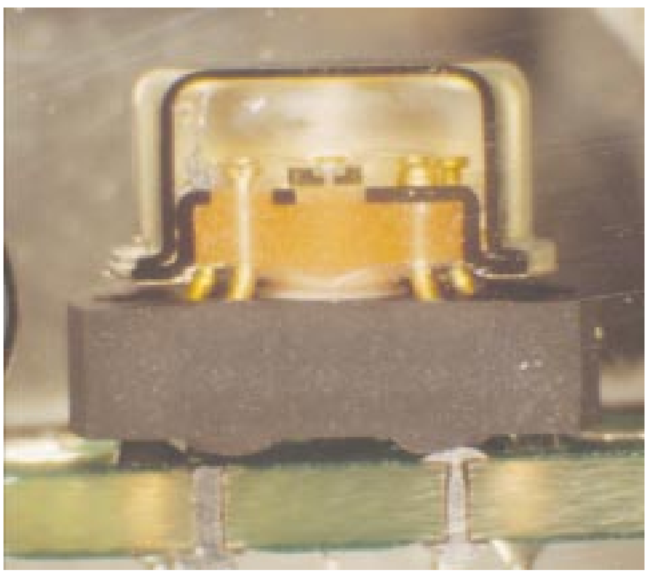

Figure 5-27

Acceptable - Class 1,2,3

- Spacer is in full contact with component and board.

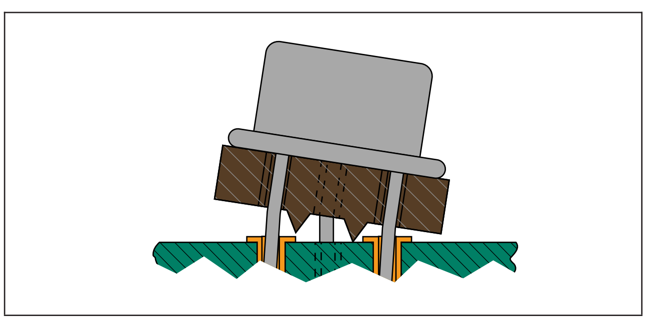

Figure 5-28

Acceptable (Supported Holes) - Class 1,2
Process Indicator (Supported Holes) - Class 3
Defect (Unsupported Holes) - Class 1,2,3

- Spacer is in partial contact with component and board.

5.2.6.1 Mounting – Vertical – Radial Leaded – Component Mounting Spacers (cont.)

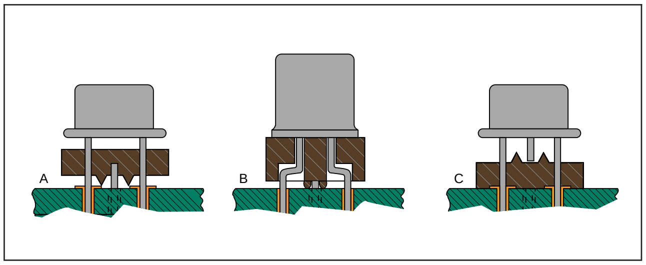

Figure 5-29

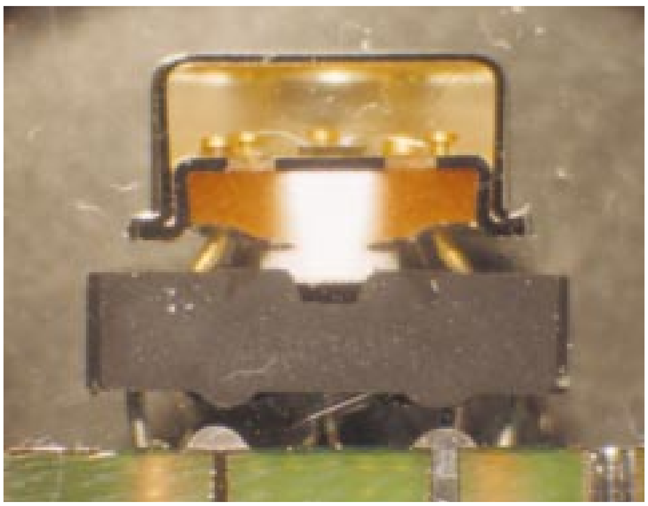

Figure 5-30

Acceptable (Supported Holes) - Class 1
Process Indicator (Supported Holes) - Class 2
Defect (Supported Holes) - Class 3
Defect (Unsupported Holes) - Class 1,2,3

A. Spacer is not in contact with component and board.
B. Lead is improperly formed.

Defect - Class 2,3

C. Spacer is inverted.

5.2.6.2 Mounting – Vertical – Radial Leaded – Component Meniscus

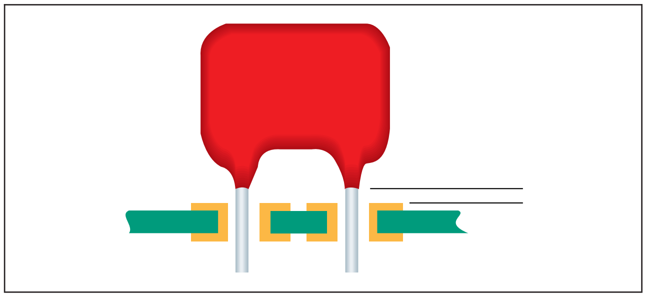

Figure 5-31

Target - Class 1,2,3

- There is discernible clearance between the coating meniscus and subsequent solder fillet, (see 6.3.4.3 for solder requirements).

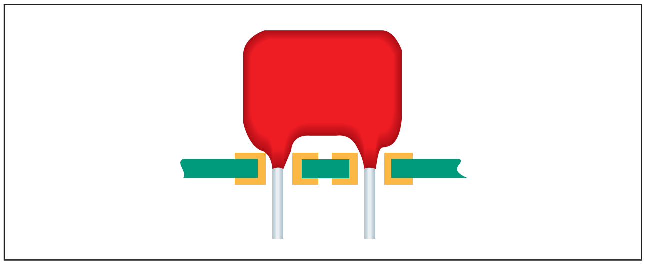

Figure 5-32

Acceptable - Class 1,2

- Components with a coating meniscus can be mounted with the meniscus into the holes provided they meet the requirements of 6.3.4.3.

Process Indicator - Class 3

- Coating meniscus is into the plated-through hole (must meet the requirements of 6.3.4.3).

5.2.7 Mounting – Wire/Lead Termination – Printed Board

5.2.7.1 Mounting – Wire/Lead Termination – Printed Board – Protrusion – Straight and Partially Clinched Leads

Lead protrusion should not allow a possibility of violating of minimum electrical spacing, damage to soldered connections due to lead deflection, or penetration of static protective packaging during subsequent handling.

Note: High frequency applications may require more precise control of lead extensions to prevent violation of functional design considerations.

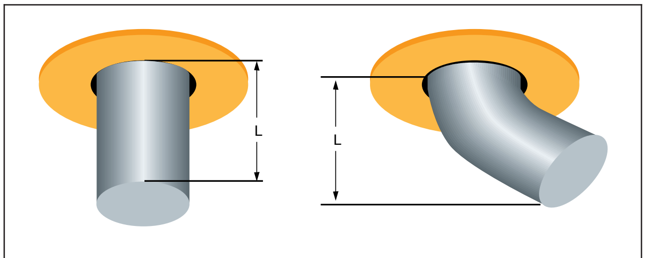

Figure 5-33

Target - Class 1,2,3

- The protrusion of leads and wires beyond the conductive surface is (L) or as specified on the specification or drawing.

(L) = 1.0 mm [0.0394 in] nominal (protrusion of the lead)

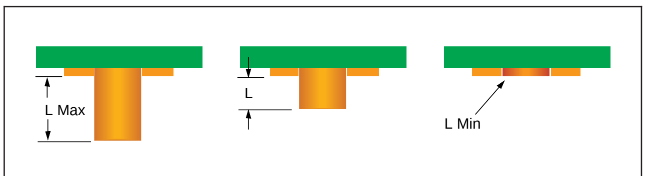

Figure 5-34

Table 5-2 Lead Protrusion

	Class 1	Class 2	Class 3
(L) min[1]	End is discernible in solder[2]		
(L) max	No danger of shorts	2.5 mm [0.0984 in]	1.5 mm [0.0591 in]

Note 1. For single-sided boards, lead or wire protrusion (L), is at least 0.5 mm [0.020 in] for Class 1 and 2. There must be sufficient protrusion for Class 3 to clinch.

Note 2. For plated-through hole boards greater than 2.3 mm [0.0906 in] thick, components with pre-established lead lengths, (DIPs,sockets), lead protrusion may not be discernible.

Process Indicator - Class 2 (Supported Hole)
Defect - Class 3 (Supported Hole)

- Lead protrusion does not meet the requirements of Table 5-2.

Defect - Class 1,2,3 (Supported Hole)

- Lead protrustion violates minimum electrical clearance.

Process Indicator - Class 2 (Unsupported Hole)
Defect - Class 3 (Unsupported Hole)

- Lead protrusion is inadequate to permit lead clinching a minimum of 45°.

Defect - Class 1,2,3 (Unsupported Hole)

- Lead protrusion is less than 0.5 mm [0.020 in].
- Lead protrusion violates minimum electrical clearance.

5.2.7.2 Mounting – Wire/Lead Termination – Printed Board – Clinched

Component leads in through-hole connections may be terminated using a straight through, a partially clinched, or clinched configuration. The clinch should be sufficient to provide mechanical restraint during the soldering process. The orientation of the clinch relative to any conductor is optional. DIP leads should be bent outward from the longitudinal axis of the body. Tempered leads are not terminated with a full-clinched configuration.

As a minimum, the lead is discernible in the completed solder connection. The lead meets the requirements of Table 5-2 when measured vertically from the land surface and does not violate minimum electrical clearance requirements.

Lead terminations in unsupported holes are clinched a minimum of 45° and the lead protrusion for unsupported holes is 0.5 mm [0.020 in] minimum and does not violate minimum electrical clearance requirements.

This section applies to terminations with a clinching requirement. Other requirements may be specified on relevant specifications or drawings. Partially clinched leads for part retention are considered as unclinched leads and need to meet protrusion requirements.

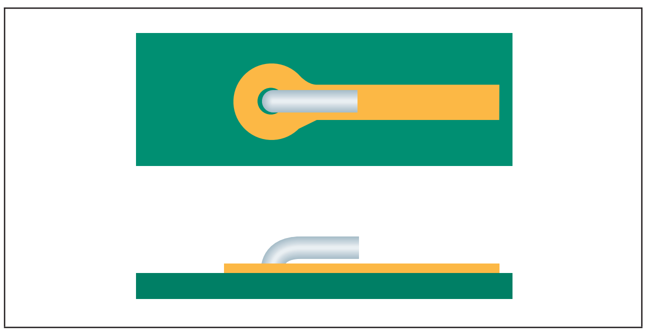

Figure 5-35

Target - Class 1,2,3

- Lead end is parallel to the board and direction of the clinch is along the connecting conductor.

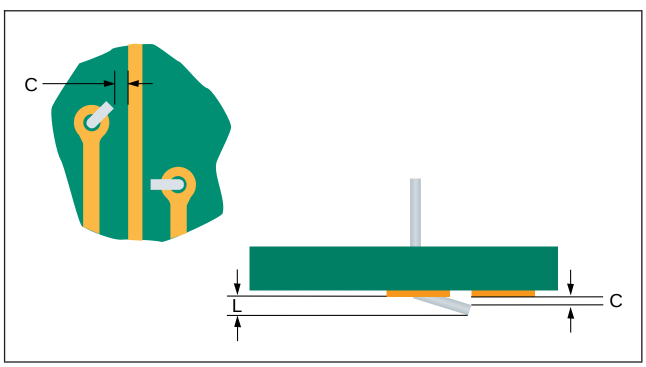

Figure 5-36

Acceptable - Class 1,2,3

- The clinched lead does not violate the minimum electrical clearance (C) between noncommon conductors.
- The protrusion (L) beyond the land is not greater than the similar length allowed for straight-through leads. See Figure 5-33 and Table 5-2.

5.2.7.2 Mounting – Wire/Lead Termination – Printed Board – Clinched (cont.)

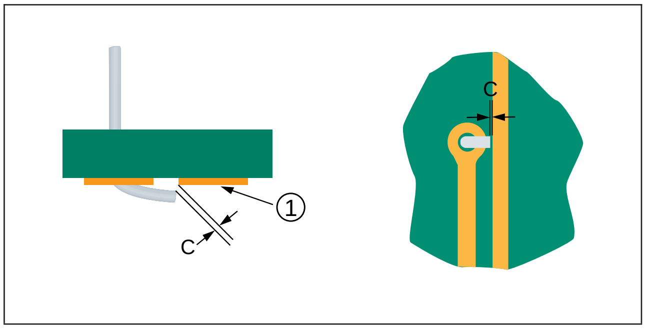

Figure 5-37
1. Noncommon conductor

Figure 5-38

Defect - Class 1,2,3

- The lead is clinched toward an electrically noncommon conductor, violating minimum electrical clearance (C).

Defect - Class 3

- Lead in unsupported hole is not clinched.

5.2.8 Mounting – Dual-in-Line Pack (DIP)/ Single-in-Line Pack (SIP) Pins and Sockets

Note: In some cases a heat sink may be located between the component and the printed board; in these cases other criteria may be specified.

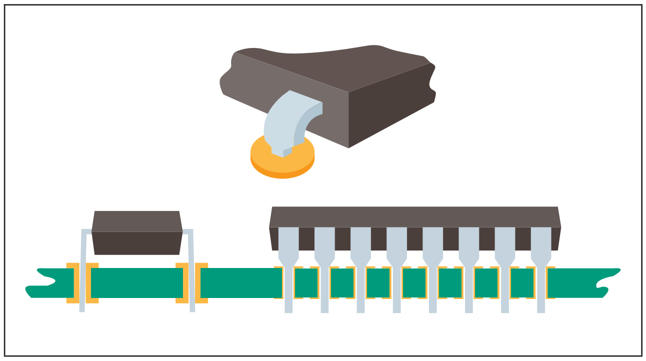

Figure 5-39

Target - Class 1,2,3

- Standoff step on all leads rests on the land.
- Lead protrusion meets requirements. See 5.2.7.1.

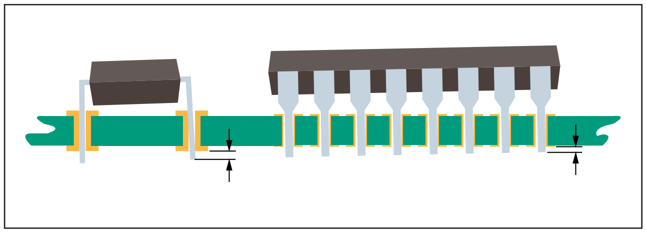

Figure 5-40

Acceptable - Class 1,2,3

- Amount of tilt is limited by minimum lead protrusion and height requirements.

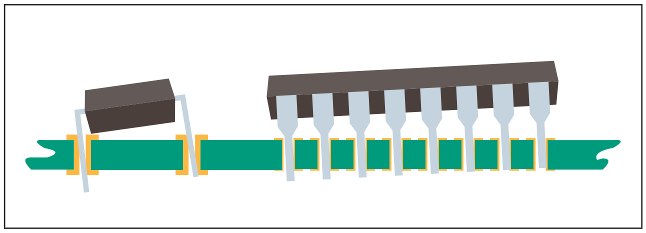

Figure 5-41

Defect - Class 1,2,3

- Tilt of the component exceeds maximum component height limits or lead protrusion does not meet acceptance requirements.

5.2.8 Mounting – Dual-in-Line Pack (DIP)/ Single-in-Line Pack (SIP) Pins and Sockets (cont.)

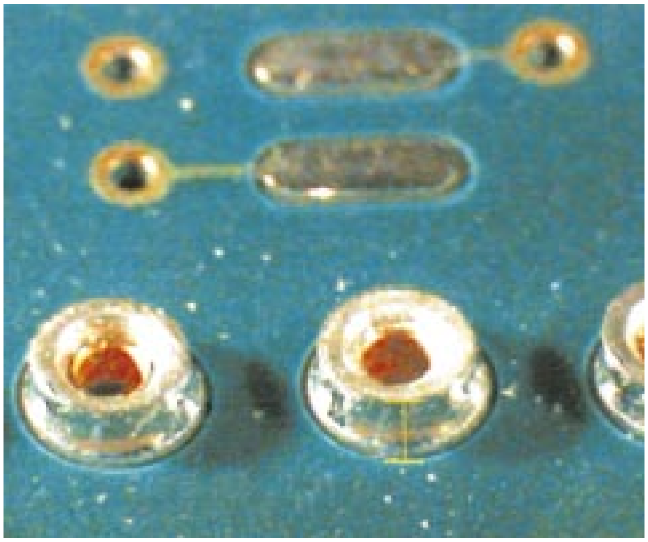

Figure 5-42

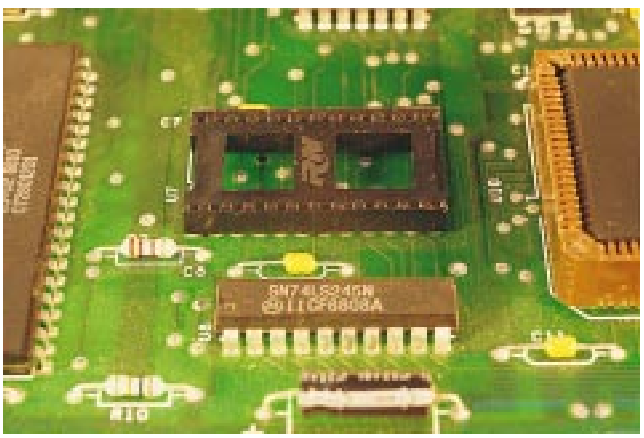

Figure 5-43

Acceptable - Class 1,2,3

• Lead protrusion and component height requirements are not violated.

5.2.9 Mounting – Connectors

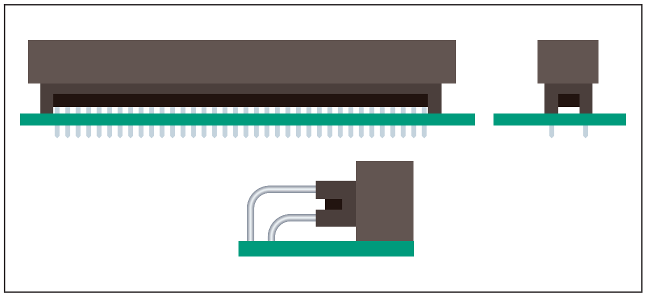

Figure 5-44

Target - Class 1,2,3

- Connector is flush with board.
- Standoff step on all leads rests on land, and lead protrusion meets requirements.
- Board lock (if equipped) is fully inserted/snapped into the board.

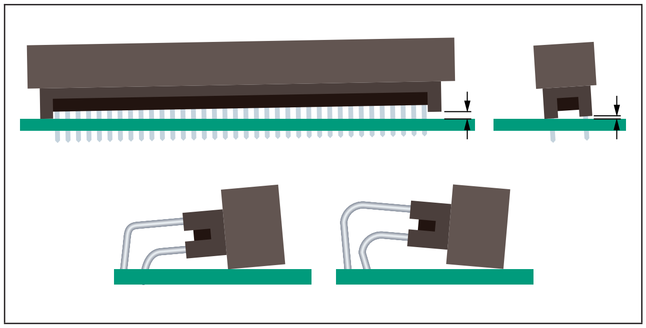

Figure 5-45

Acceptable - Class 1,2,3

- Back edge of connector is flush; entering edge of connector does not violate component height or lead protrusion requirements. See 5.2.7.1.
- Board lock is fully inserted/snapped through the board. (Nonfloating housing.)
- With one edge touching the board, the other edge is not more than 0.5 mm [0.020 in] off the board (floating housing). Amount of tilt is limited by minimum lead protrusion and height requirements.

5.2.9 Mounting – Connectors (cont.)

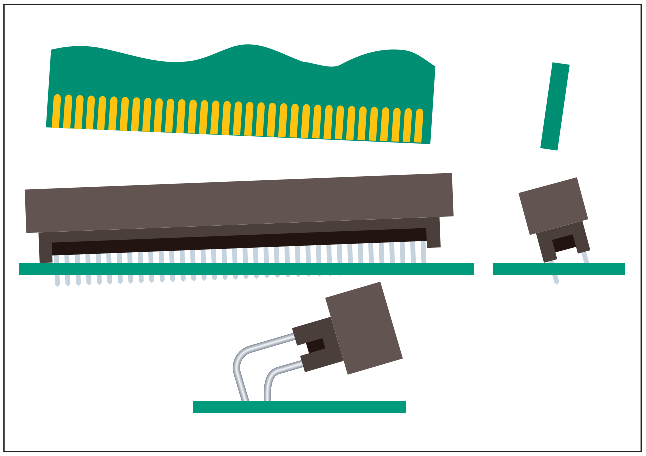

Figure 5-46

Defect - Class 1,2,3

- Will not mate when used in application due to angle.
- Component violates height requirements.
- Boardlock is not fully inserted/snapped into board.
- Lead protrusion does not meet acceptance requirements.

Note: Connectors need to meet form, fit and function requirements. A trial mating of connector to connector or to assembly may be required for final acceptance.

5.2.10 Mounting – Leads Crossing Conductors

Sleeving must be used when called for by specification or drawing.

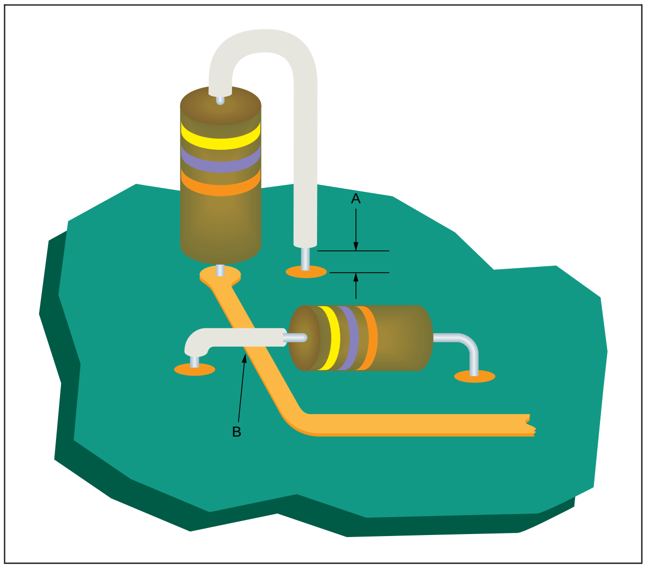

Figure 5-47

Acceptable - Class 1,2,3

A. Sleeve does not extend into solder connection.
B. Sleeve covers area of protection designated.

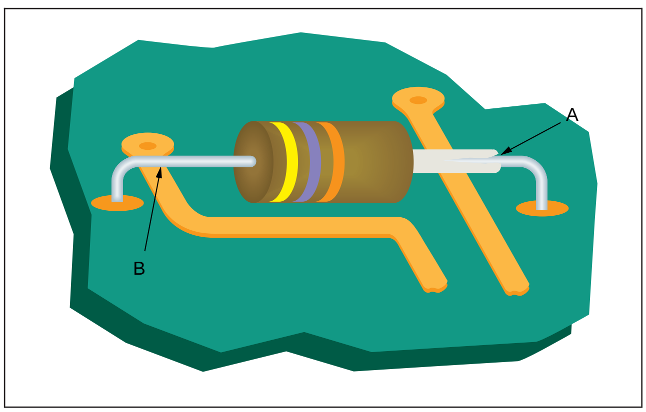

Figure 5-48

Acceptable - Class 1

- Component lead crossing an electrically noncommon conductor that does not violate electrical spacing.

Defect - Class 2,3

A. Splitting and/or unraveling of sleeving.
B. A component lead crossing an electrically noncommon conductor with a clearance of less than 0.5 mm [0.020 in] with no separating insulator (lead sleeving or surface coating).

Defect - Class 1,2,3

- Component leads and wires specified to have sleeving are not sleeved.
- Damaged/insufficient sleeving no longer provides protection from shorting.

5.3 Lead Forming

5.3.1 Lead Forming – Bends

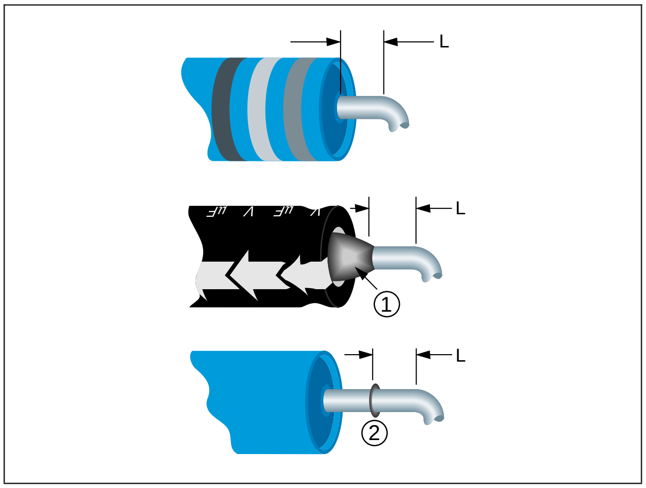

Figure 5-49
1. Solder bead
2. Weld

Acceptable - Class 1,2,3

- Leads for through-hole mounting extend at least one lead diameter or thickness but not less than 0.8 mm [0.031 in] from the body, solder bead, or lead weld.

Figure 5-50

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Lead bend in through-hole mounted component is less than one lead diameter or 0.8 mm [0.031 in], whichever is less, from the component body, solder bead or component body lead seal.

Defect - Class 1,2,3

- Fractured lead weld, solder bead, or component body lead seal.

5.3.1 Lead Forming – Bends (cont.)

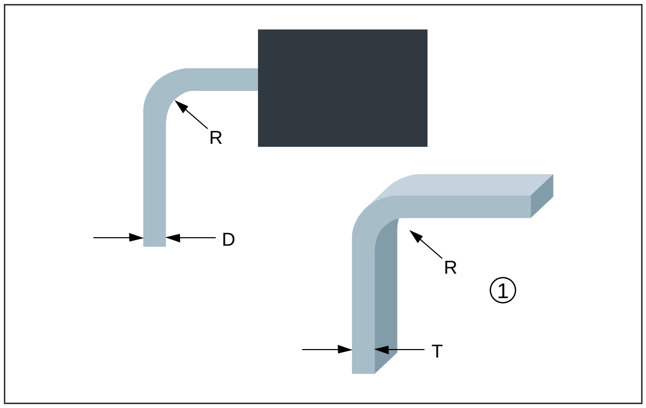

Figure 5-51

1. Rectangular leads shall use the thickness (T) as the lead diameter (D)

Acceptable - Class 1,2,3

- Lead is not kinked or cracked.
- The minimum inside bend radius of component leads is per Table 5-3.

Table 5-3 Minimum Inside Bend Radius

Lead Diameter (D) or Thickness (T)	Minimum Inside Bend Radius (R)
Less than 0.8 mm [0.031 in]	1 Diameter/Thickness
From 0.8 mm [0.031 in] to 1.2 mm [0.0472 in]	1.5 Diameter/Thickness
Larger than 1.2 mm [0.0472 in]	2 Diameter/Thickness

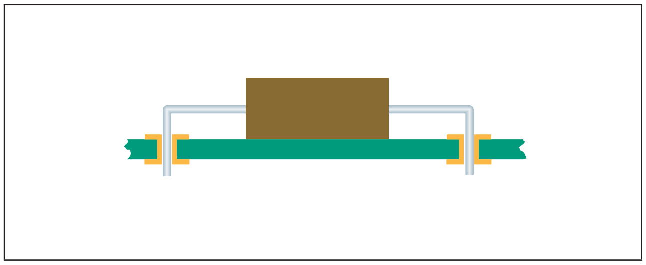

Figure 5-52

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The inside bend radius does not meet requirements of Table 5-3.

5.3.2 Lead Forming – Stress Relief

Components are to be mounted in any one or a combination of the following configurations:

• In a conventional manner utilizing 90° (nominal) lead bends directly to the mounting hole.

• With camel hump bends. Configuration incorporating a single camel hump may have the body positioned off-center.

• Other configurations may be used with agreement of the customer or where design restraints exist.

5.3.2.1 Lead Forming – Stress Relief – Supported Holes

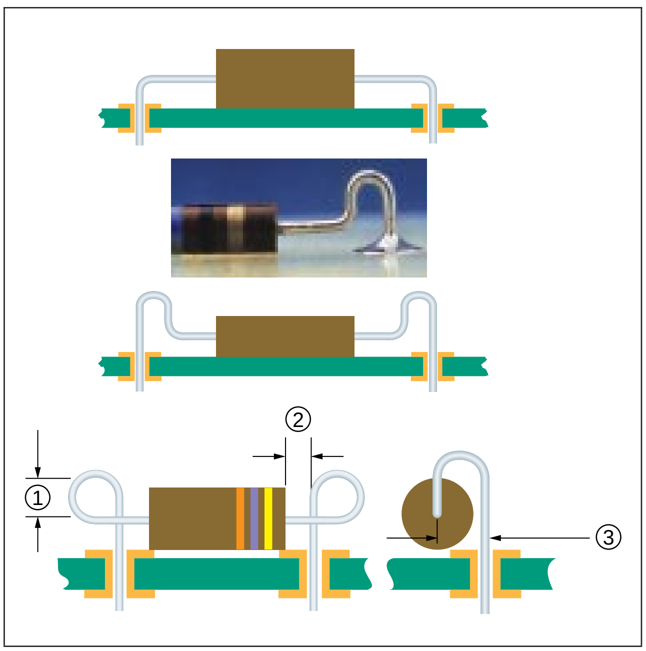

Figure 5-53

1. 4 wire diameters minimum, 8 wire diameters maximum
2. 1 wire diameter minimum
3. 2 wire diameters minimum

Acceptable - Class 1,2,3

• Component lead exiting component body is approximately parallel to major body axis.

• Component lead entering hole is approximately perpendicular to board surface.

• Component centering may be offset as a result of the type of stress relief bend made.

Note: Loop bends and other alternative stress relief bends may be used if the location of the mounting holes prevent the use of a standard bend. Make sure there is no possibility of shorting the lead to any adjacent component lead or conductor. Use of a loop bend needs to be approved by design engineering. See IPC-2221.

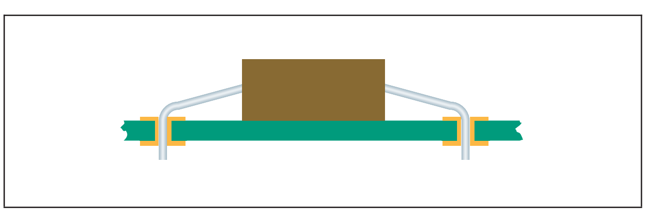

Figure 5-54

Defect - Class 1,2,3

• No stress relief

Acceptable - Class 1,2,3

• Leads are formed to provide stress relief.

5.3.2.1 Lead Forming – Stress Relief – Supported Holes (cont.)

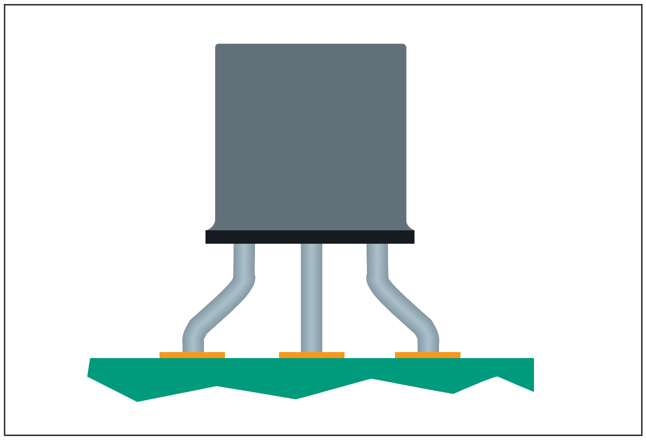

Figure 5-55

Note: Prepped components such as this one usually cannot meet the maximum spacing requirements of a straight-legged vertical - radial leaded component. See 5.2.6. Maximum space between component and board surface is determined by considering design limitations and product use environments. The component preparation equipment and manufacturer's suggested component lead bend specifications and capabilities determine limitation. This may require change in tooling to meet requirements for end use.

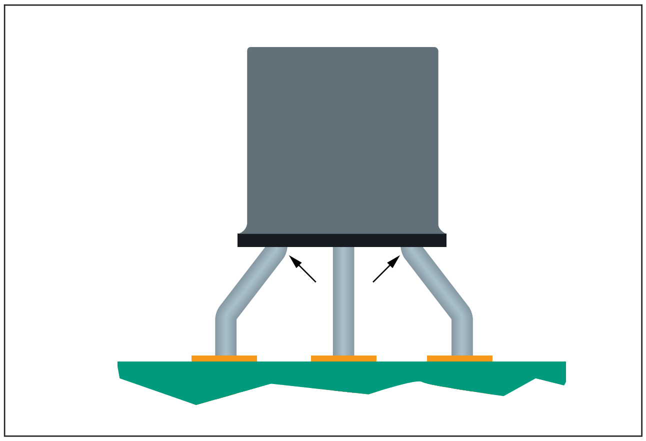

Figure 5-56

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Lead bends less than one lead diameter away from body seal.

Defect - Class 1,2,3

- Damage or fracture of component body to lead seal.

5.3.2.2 Lead Forming – Stress Relief – Unsupported Holes

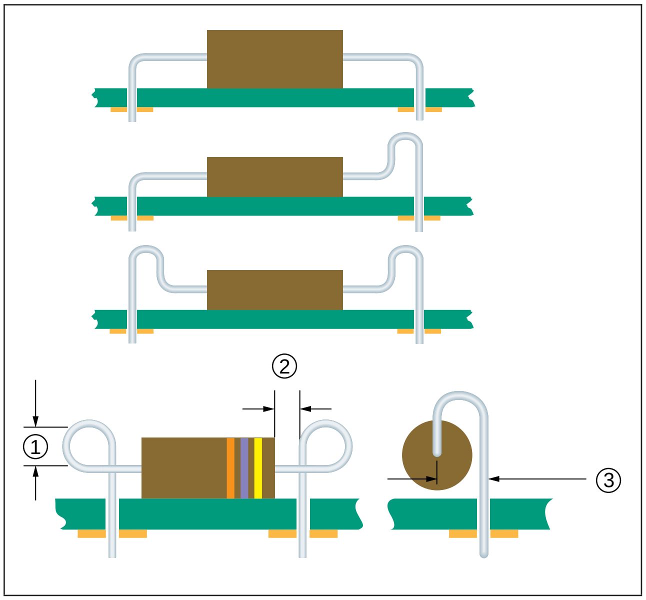

Figure 5-57

1. 4 wire diameter minimum
   8 wire diameter maximum
2. 1 wire diameter minimum
3. 2 wire diameter minimum

Acceptable - Class 1,2,3

- Component lead exiting component body is approximately parallel to major body axis.
- Component lead entering hole is approximately perpendicular to board surface.

Note: Loop bends may be used if the location of the mounting holes prevent the use of a standard bend. Make sure there is no possibility of shorting the lead to any adjacent component lead or conductor. Use of a loop bend needs to be approved by Design Engineering.

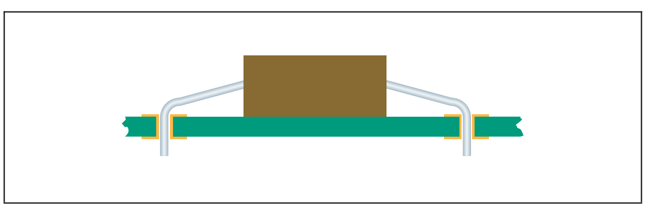

Figure 5-58

Defect - Class 1,2,3

- No stress relief.

5.3.2.3 Lead Forming – Stress Relief – Terminals

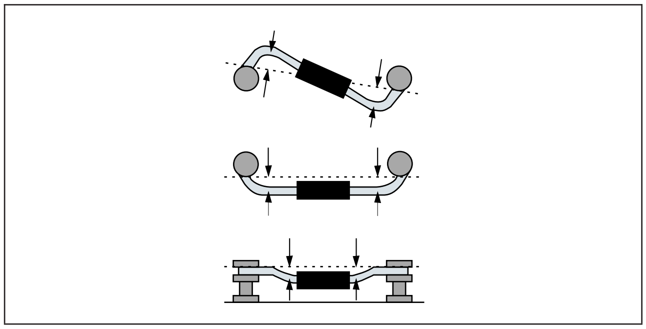

Figure 5-59

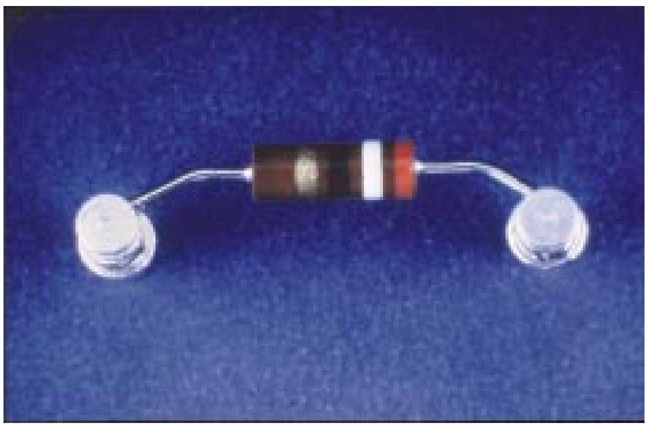

Figure 5-60

Target - Class 1,2,3

- Component body centerline to terminal edge is at least one-half (50%) the component diameter or 1.3 mm [0.0511 in], whichever is greater. For components less than 6 mm [0.24] in diameter, the measurement is to the near edge of the terminal.
- For clip and adhesive mounted components and for conformally coated assemblies, both leads have stress relief.

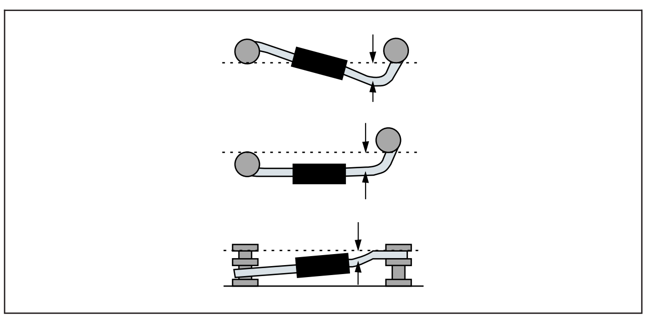

Figure 5-61

Acceptable - Class 1,2,3

- One lead has minimal stress relief bend, provided the component is not clip or adhesive mounted, or otherwise constrained.

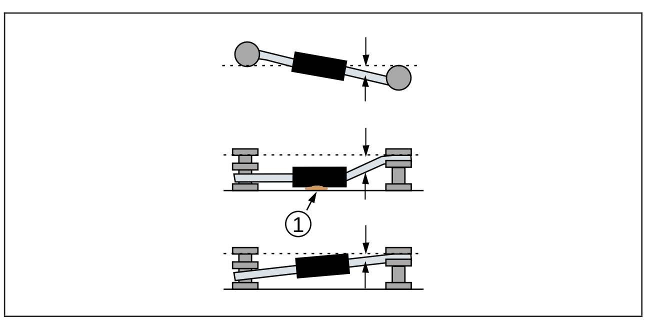

Figure 5-62
1. Adhesive

Defect - Class 1,2,3

- No stress relief.

5.4 Damage

5.4.1 Damage – Lead

Figure 5-63

Acceptable - Class 1,2,3

- Whether leads are formed manually or by machine or die, parts or components are not to be mounted if the part or component lead has nicks or deformation exceeding 10% of the diameter, width or thickness of the lead. See 6.5.2 for exposed basis metal criteria.

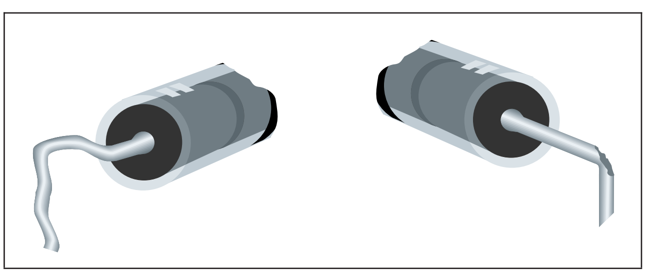

Figure 5-64

Defect - Class 1,2,3

- Lead is damaged more than 10% of the lead diameter.
- Lead deformed from repeated or careless bending.

5.4.1 Damage – Lead (cont.)

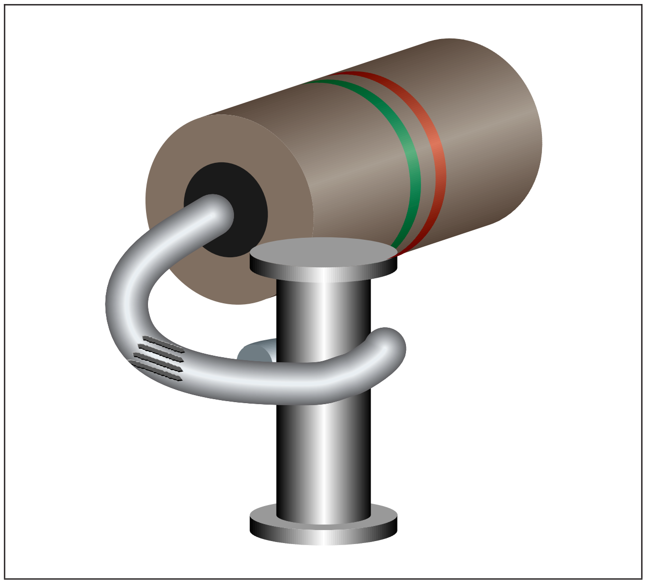

Figure 5-65

Defect - Class 1,2,3

- Heavy indentations, a serrated plier mark. Lead diameter is reduced more than 10%.

5.4.2 Damage – DIP and SOIC

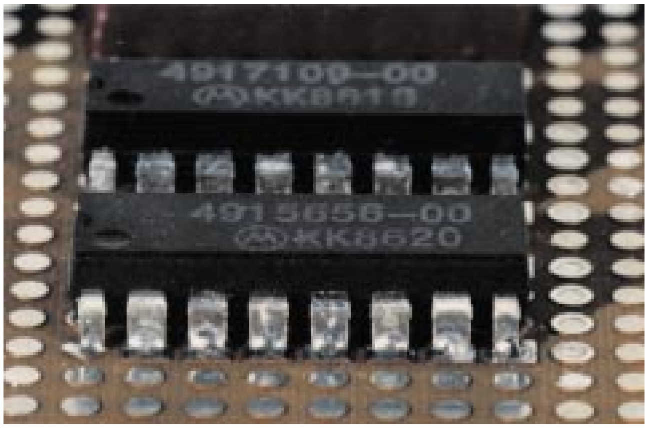

Figure 5-66

Target - Class 1,2,3

- No chip outs, cracks or damaged finish.

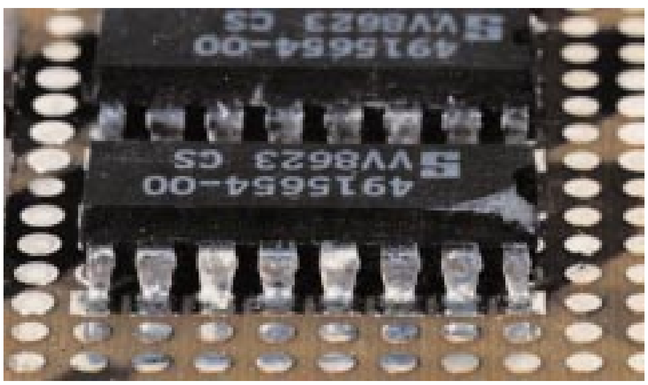

Figure 5-67

Acceptable - Class 1
Process Indicator - Class 2,3

- Chip outs in the lid or case do not extend into the seal area.
- There are no cracks extending into the seal from any chip out.
- There is no pertinent identification missing due to a chip out.

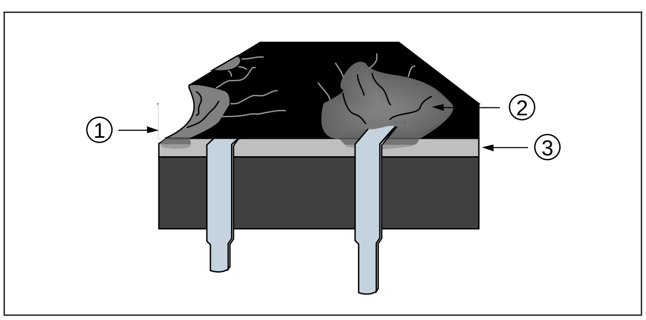

Figure 5-68
1. Chip enters seal
2. Exposed lead
3. Seal

Defect - Class 1,2,3

- Chip out enters into the seal.
- Chip out exposes the lead in an area not normally exposed.
- There are cracks leading from the chip out.

5.4.3 Damage – Axial Lead and Glass Body/Seal

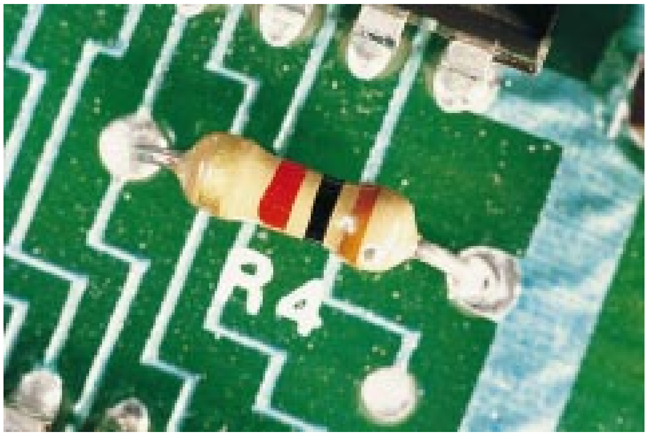

Figure 5-69

Acceptable - Class 1
Process Indicator - Class 2,3

- Visible chip in surface coating of component body and internal functional element is not exposed.

Figure 5-70

Defect - Class 1,2,3

- The insulating cover is damaged to the extent that the internal functional element is exposed or the component shape is deformed.

5.4.3 Damage – Axial Lead and Glass Body/Seal (cont.)

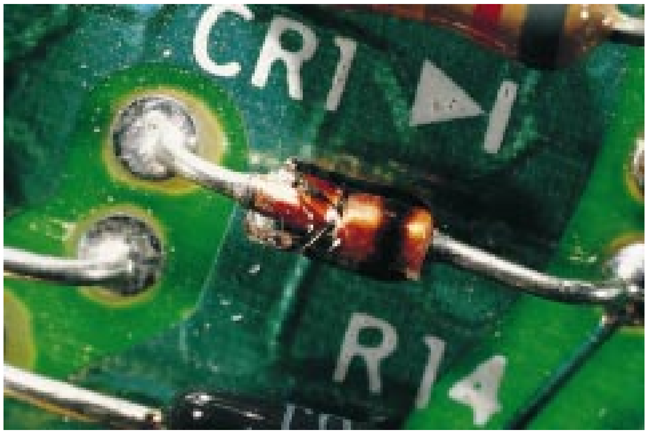

Figure 5-71

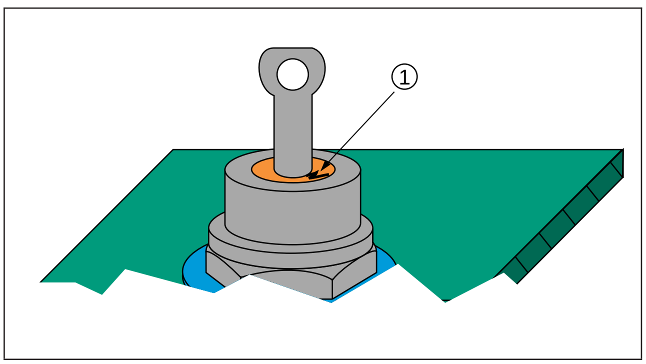

Figure 5-72
1. Cracked insulator

Defect - Class 1,2,3

- Chips or cracks in glass body in excess of component specification limits.
- Crack in glass insulator/seal.
- Cracked or damaged glass bead (not shown).

5.4.4 Damage – Radial (Two Lead)

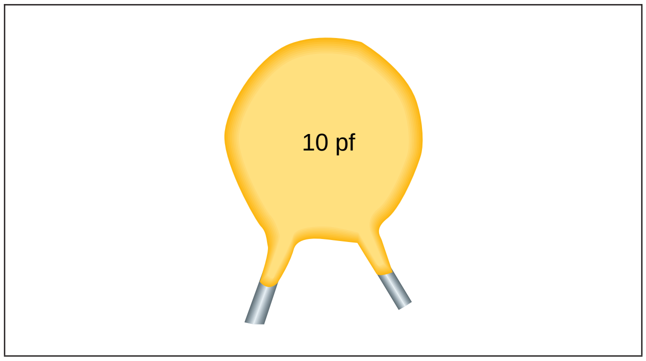

Figure 5-73

Target - Class 1,2,3

- Component bodies are free of scratches, chips, and crazing. ID markings are legible.

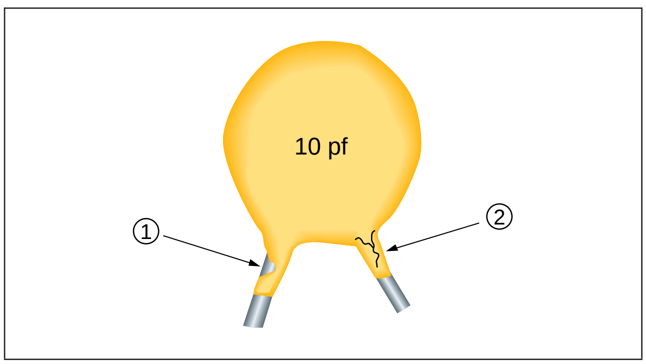

Figure 5-74
1. Chip
2. Crack

Acceptable - Class 1,2,3

- Minor surface scratches, cuts, or chips that do not expose the component substrate or active area.
- Structural integrity is not compromised.

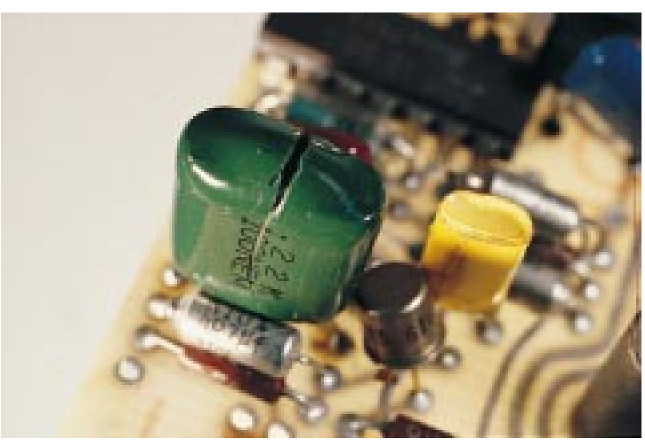

Figure 5-75

Defect - Class 1,2,3

- Active area is exposed or structural integrity is compromised.

5.5 Terminals

5.5.1 Terminals – Wrap

Applies to both wires and component leads. The text associated with each terminal type in the following illustrations apply only to that terminal type.

5.5.1.1 Terminals – Wrap – Turrets and Straight Pins

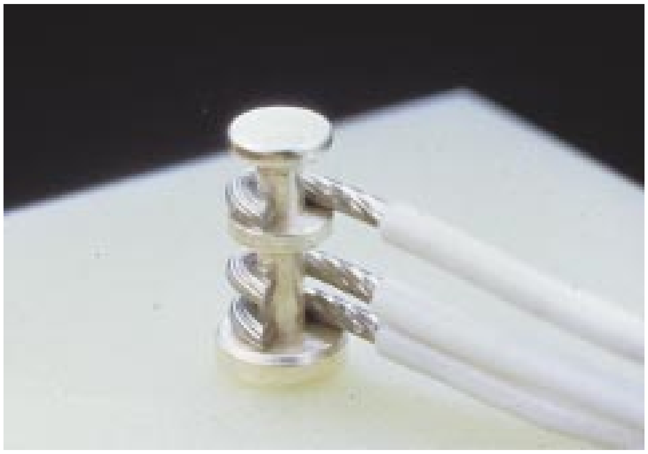

Figure 5-76

Target - Class 1,2,3

- Wraps parallel to each other and to the base.
- Wire mounted against terminal base.
- On straight pins, the top wire on terminal is one wire diameter below the top of the terminal.
- Wraps are a minimum of 180° and a maximum of 270°.

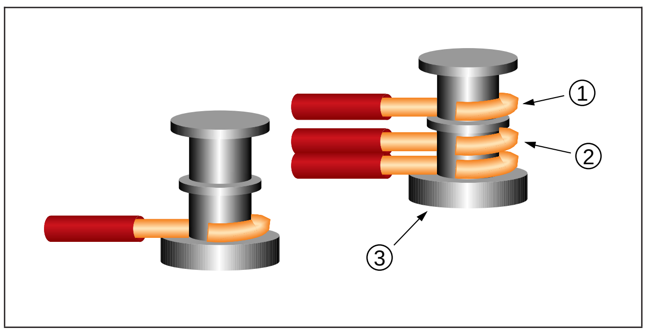

Figure 5-77
1. Upper guide slot
2. Lower guide slot
3. Base

Acceptable - Class 1,2,3

- Wires and leads mechanically secure to terminals before soldering.
- Wires and leads wrapped a minimum of 180° and do not overlap.

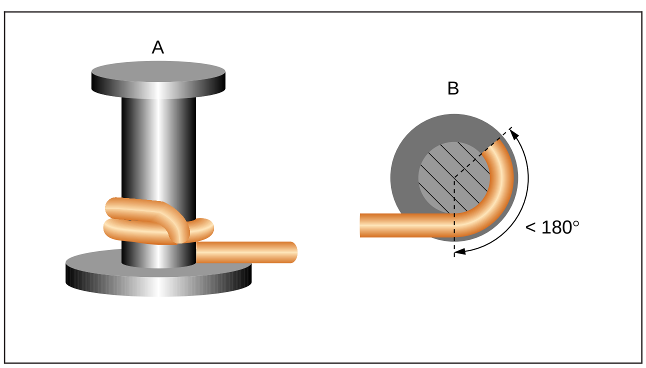

Figure 5-78

Process Indicator - Class 2,3

A. Wire end overlaps itself.

Process Indicator - Class 2
Defect - Class 3

B. Minimum wrap for round posts has less than 180° of contact between the wires and the terminal.

5.5.1.2 Terminals – Wrap – Bifurcated Terminals

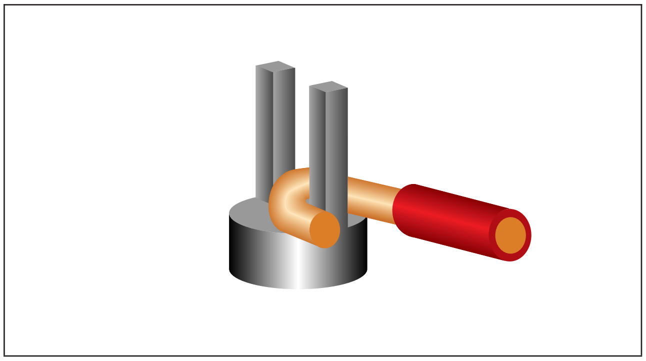

Figure 5-79

Target - Class 1,2,3

- The wire or lead contacts two parallel faces (180° bend) of the terminal post.
- The cut end of the wire contacts the terminal.
- No overlapping of wraps.
- Wires placed in ascending order with largest on the bottom.
- Multiple wire attachments alternate terminal posts.

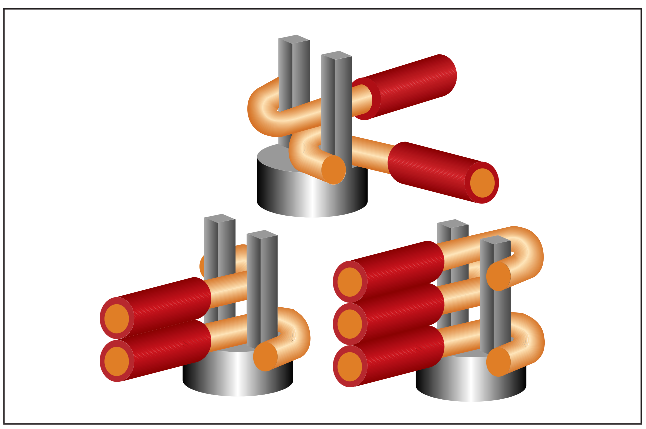

Figure 5-80

Acceptable - Class 1,2,3

- Wire ends may extend beyond the base of the terminal providing minimum electrical spacing is maintained.
- Wire passes through the slot and makes positive contact with at least one corner of the post.
- Wires/leads 0.75 mm [0.0295 in] or larger in diameter are routed straight through the posts.
- The number of attachments does not exceed the top of terminal post.

5.5.1.2 Terminals – Wrap – Bifurcated Terminals (cont.)

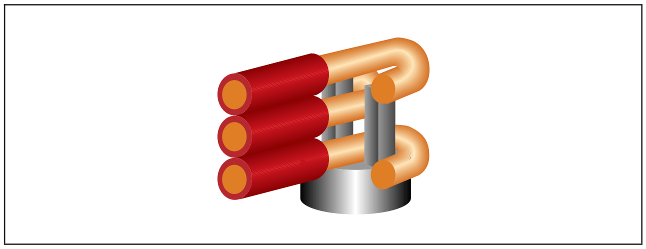

Figure 5-81

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The number of attachments exceed top of terminal post.
- Minimum wrap is less than 90° around the terminal except solid wires or leads 0.75 mm [0.0295 in] or greater diameter.
- Wire does not pass through slot.

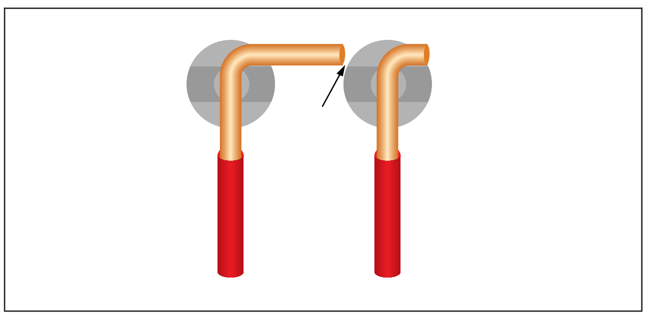

Figure 5-82

Defect - Class 1,2,3

- Excessively long wire end violates minimum electrical clearance.

5.5.1.2 Terminals – Wrap – Bifurcated Terminals (cont.)

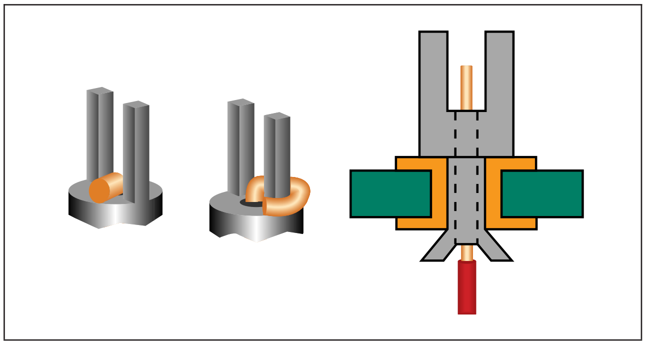

Figure 5-83

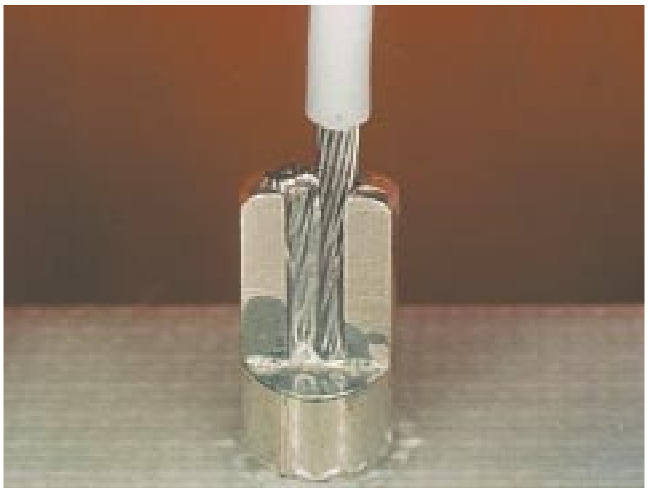

Figure 5-84

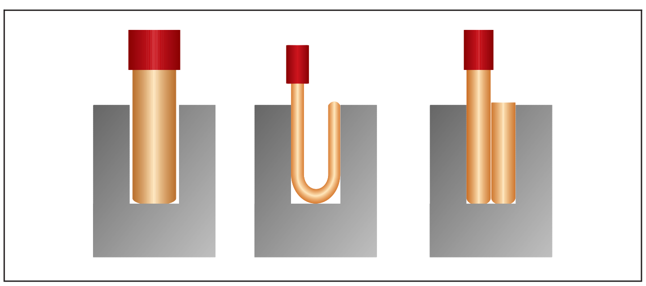

Figure 5-85

Target - Class 1,2,3

- Wire insulation does not enter base or posts of terminal.
- Bottom route wire wrap contacts two parallel sides of post (180°).
- Wire is against base of terminal.
- Top route wire has space between posts filled by using a separate filler or bending the wire double.

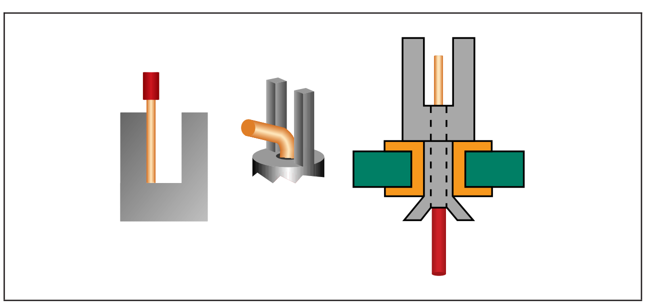

Figure 5-86

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Wire insulation enters base or posts of terminal.
- Top route wire is not supported with filler.
- Bottom route wire not wrapped to terminal base or post with a minimum 90° bend.

5.5.1.3 Terminals – Wrap – Pierced/Perforated Terminals

Figure 5-87

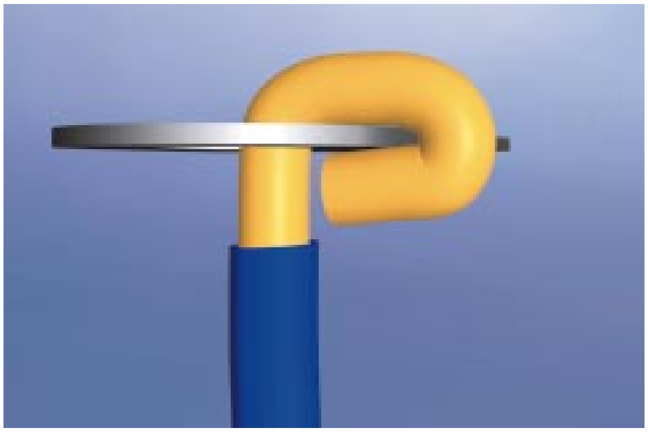

Figure 5-88

Target - Class 1,2,3

- Wire passes through the eye of the terminal.
- Wire wrapped to contact two sides of the terminal.
- Insulation clearance less than two wire diameters.

Figure 5-89

Defect - Class 1,2,3

- Wire end violates minimum electrical clearance to noncommon conductor (not shown).

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Wire wrap less than 90°.
- Wire does not pass through the eye of the terminal.

5.5.1.4 Terminals – Wrap – Hook Terminals

Figure 5-90

Target - Class 1,2,3

- Wire wrap contacts terminal for a minimum of 180°.
- Minimum of one wire diameter space from end of hook to the closest wire.
- Wires attached within the 180° arc of the hook.
- Wires do not overlap.
- Insulation clearance less than two wire diameters.

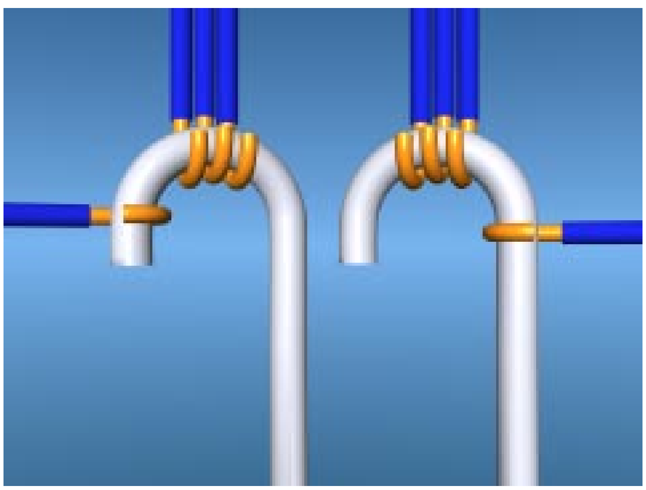

Figure 5-91

Acceptable - Class 1,2,3

- Wire contacts and wraps terminal at least 180°.
- No overlap of wire turns.
- Minimum of one wire diameter space from end of hook to the closest wire.

5.5.1.4 Terminals – Wrap – Hook Terminals (cont.)

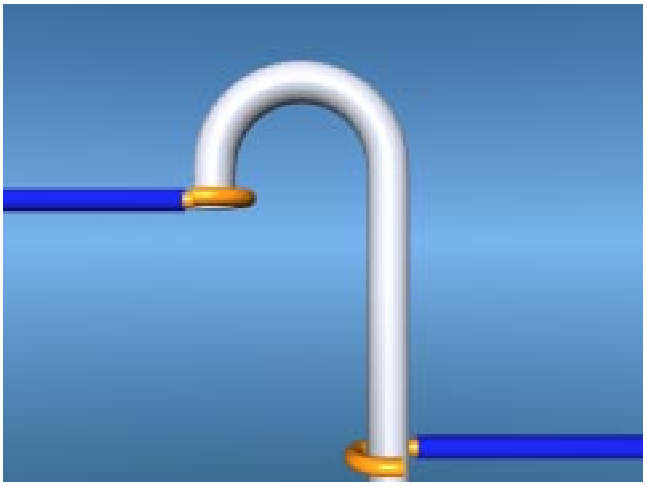

Figure 5-92

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Wire is wrapped less than one wire diameter from end of hook.
- Wire wrap is less than 180°.
- Wire is attached outside the arc of the hook and is less than two lead diameters or 1.0 mm [0.039 in] whichever is greater from the base of the terminal.

Defect - Class 1,2,3

- Wire end violates minimum electrical clearance to noncommon conductor.

5.5.1.5 Terminals – Wrap – Series Connected Terminals

When three or more terminals are connected by a common bus wire, the end terminals shall meet the required wrap for individual terminals.

Figure 5-93

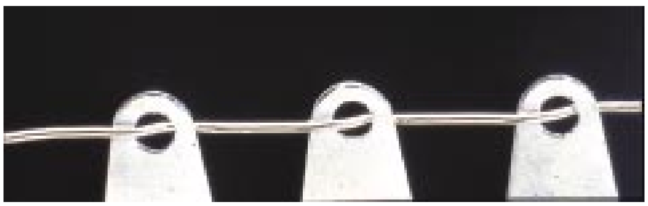

Figure 5-94

Target - Class 1,2,3

- Stress relief radii between each terminal.
- Turrets - Wire contacts base of terminal or a previously installed wire, and wraps around or interweaves each terminal.
- Hooks - Wire wraps 360° around each terminal.
- Bifurcated - Wire passes between posts and contacts base of terminal or previously installed wire.
- Pierced/Perforated - Wire contacts two nonadjacent sides of each terminal.

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Turrets - Wire does not wrap 360° around each inner terminal or is not interwoven between terminals.
- Hooks - Wire wraps less than 360° around inner terminal.
- Bifurcated - Wire does not pass between the posts or is not in contact with the terminal base or a previously installed wire.
- Pierced/Perforated - Wire does not contact two nonadjacent sides of each inner terminal.

Defect - Class 1,2,3

- No stress relief between any two terminals.

5.5.1.6 Terminals – Wrap – AWG 30 and Smaller Diameter Wires

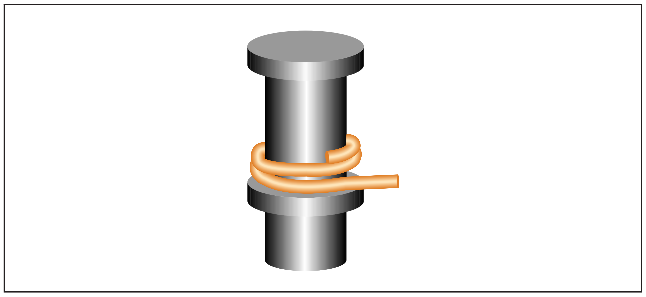

Figure 5-95

Target - Class 1,2,3

- Wire has two wraps (720°) around terminal post.
- Wire does not overlap or cross over itself or other wires terminated on the terminal.

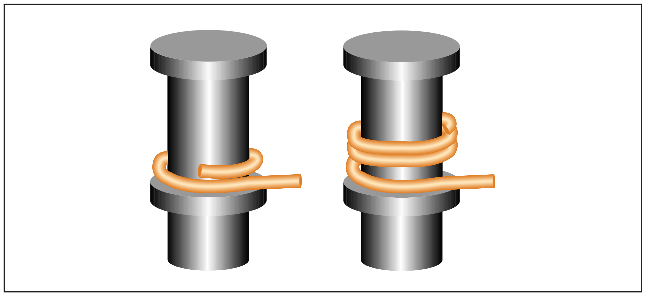

Figure 5-96

Acceptable - Class 1,2,3

- Wire has more than one wrap but less than three.

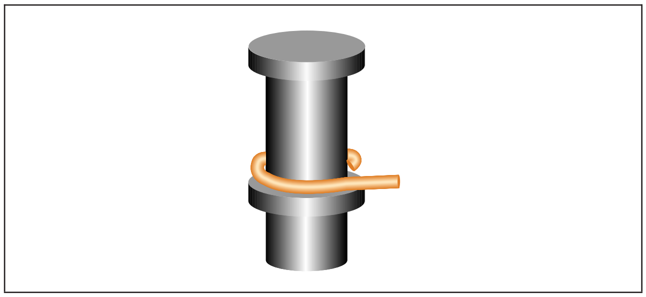

Figure 5-97

Defect - Class 2

- Wire has less than 180° wrap.

Process Indicator - Class 2
Defect - Class 3

- Wire has less than one wrap around terminal.

5.5.1.7 Terminals – Wrap – Staked Wires/Components

As an alternative to wrap requirements, the following criteria applies only to wires/leads/components which are staked or bonded.

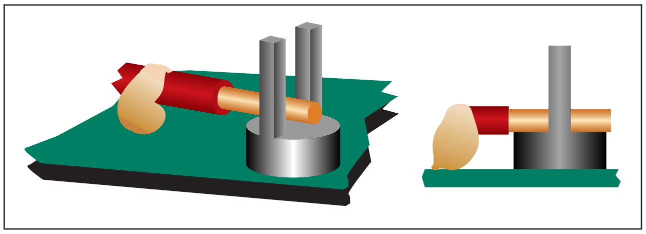

Figure 5-98

Target - Class 1,2,3

- Wire terminated with a 90° bend or inserted straight through bifurcated posts or opening in pierced/perforated terminal with mechanical support.
- Wire is permanently staked to PWB surface to prevent movement during the soldering operation.
- Component body is bonded to the PWB surface or restrained by a permanent mounting device to prevent movement during the soldering operation.
- Wire contacts base of terminal or the previous wire.
- Wire extends through posts of bifurcated terminal.
- Wire extends beyond the eye of pierced/perforated terminals.
- Wire contacts two sides of pierced/perforated terminals.

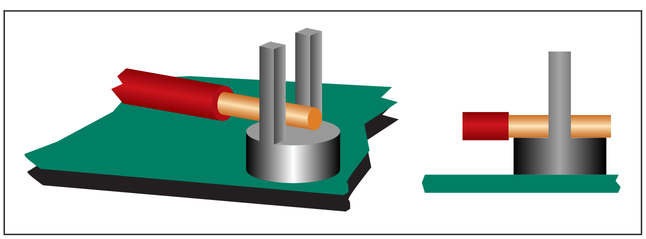

Figure 5-99

Process Indicator - Class 2
Defect - Class 3

- Wire not staked to PWB or component body not bonded to PWB or retained by a mounting device prior to soldering.
- Wire does not extend through posts of bifurcated terminal or the eye of pierced/perforated terminal.
- Wire does not contact base of bifurcated terminal or two sides of pierced/perforated terminal.

5.5.2 Terminals – Solder Cups

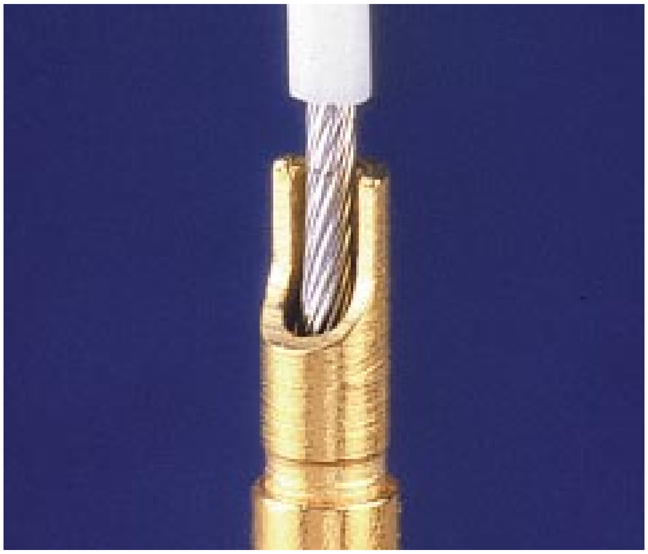

Figure 5-100

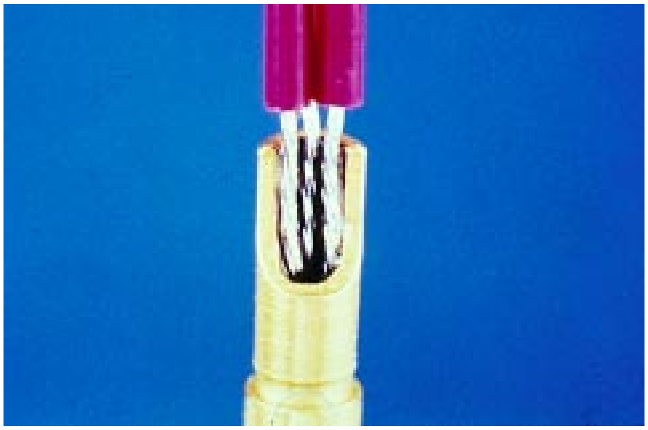

Figure 5-101

Target - Class 1,2,3

- Solder cups having the wire(s) inserted straight in and contact the back wall or other inserted wires for the full depth of the cup.

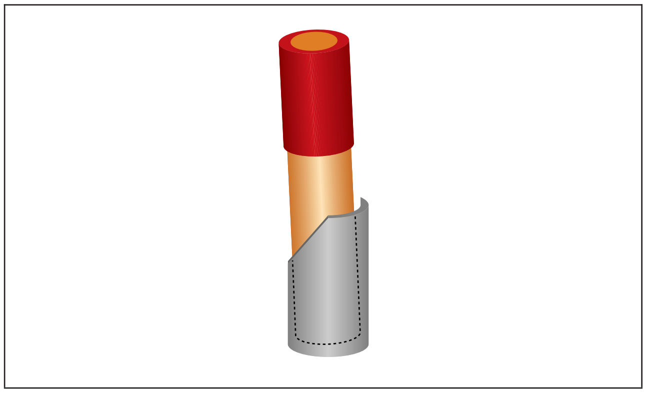

Figure 5-102

Acceptable - Class 1,2,3

- Wire(s) inserted for full depth of cup, but not in contact with back wall.

Defect - Class 2,3

- Solder cup altered to accept oversized wire or wire group.

Defect - Class 1,2,3

- Strands not in conformance with 5.7.2.

5.5.3 Terminals – Stress Relief Lead/Wire Bend

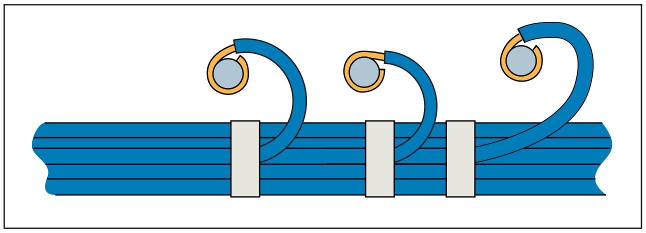

Figure 5-103

Acceptable - Class 1,2,3

- The wire approaches the terminal with a loop or bend sufficient to relieve any tension on the connection during thermal/vibration stress.

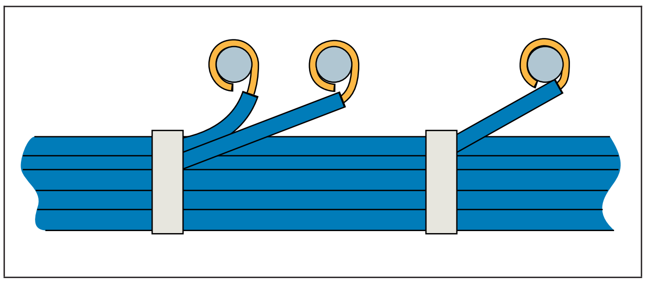

Figure 5-104

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- There is insufficient stress relief.
- The wire is under stress at the wrap.

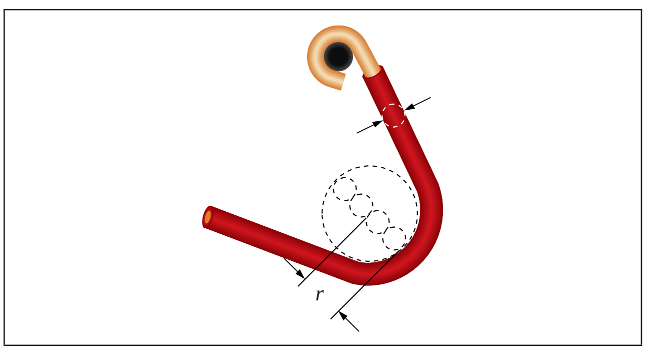

Figure 5-105

Acceptable - Class 1,2,3

- The direction of the stress-relief bend places no strain on the mechanical wrap or the solder connection.
- Bend not touching terminal is in conformance with Table 5-3.

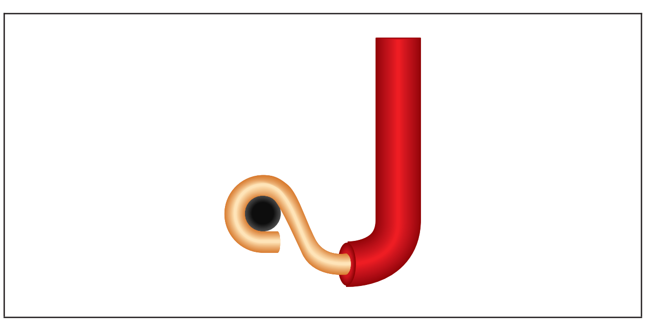

Figure 5-106

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The wire is formed around the terminal opposite to the feed-in direction.

5.5.3 Terminals – Stress Relief Lead/Wire Bend (cont.)

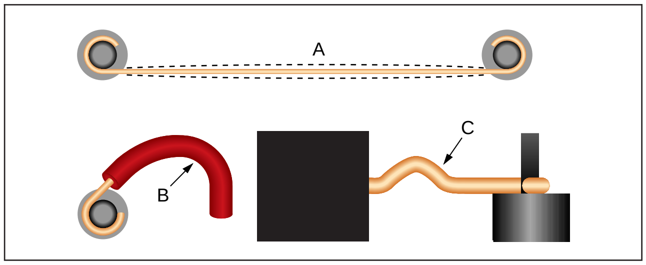

Figure 5-107

Acceptable - Class 1,2,3

A. The wire is straight between the connections with no loop or bend, but wire is not taut.

B,C. Bends are not kinked. See Table 5-3.

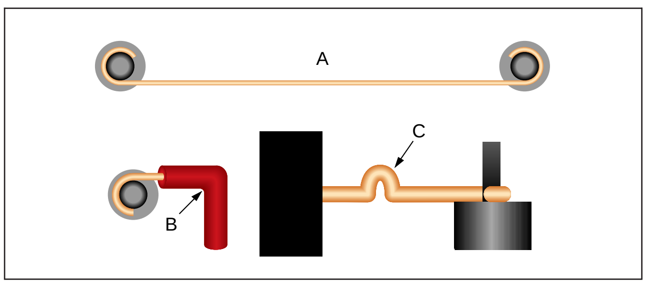

Figure 5-108

Defect - Class 1,2,3

A. Wire is stretched taut between the terminals.

B. Does not meet bend radius requirements. See Table 5.3.

C. Bends are kinked.

5.5.4 Terminals – Service Loops

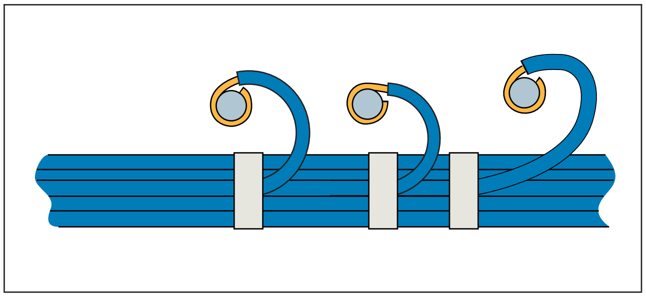

Figure 5-109

Acceptable - Class 1,2,3

- Sufficient service loop is provided to allow one field repair to be made.

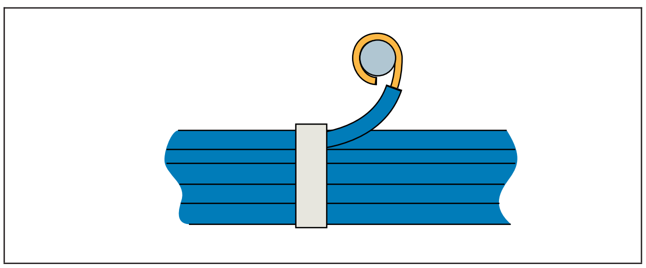

Figure 5-110

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- The wire is too short to allow an additional wrap if repair is necessary.

5.5.5 Terminals – Lead/Wire Placement

Applies equally to wires and component leads.

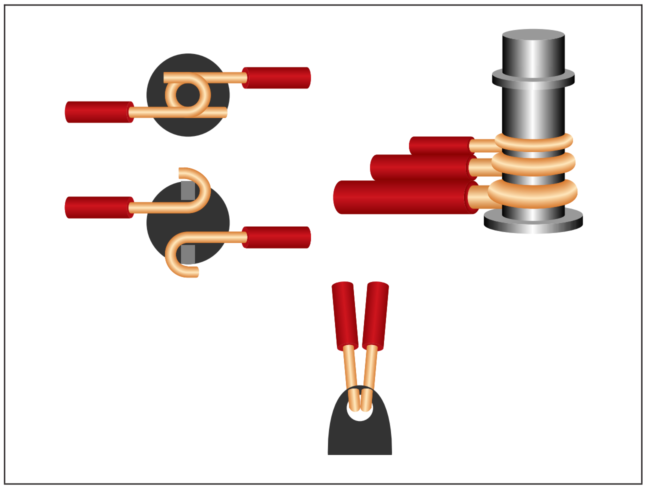

Figure 5-111

Acceptable - Class 1,2,3

- Wraps to a terminal parallel with terminal base and each other.
- Wires mounted as close to the terminal base as allowed by the insulation.
- Wrapped conductors do not cross over or overlap each other on terminal.

Process Indicator - Class 2
Defect - Class 3

- Wrapped conductors cross over or overlap each other on terminal.

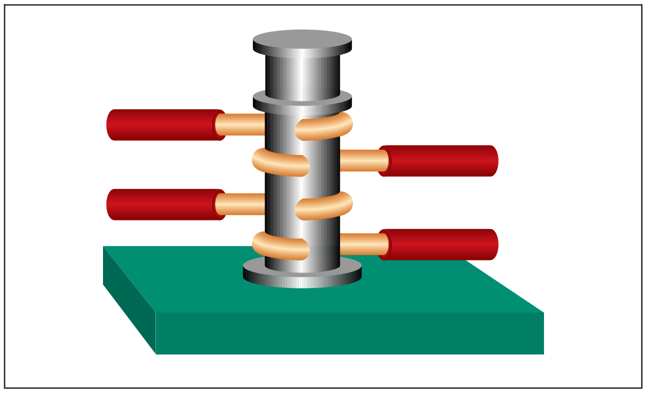

Figure 5-112

Acceptable - Class 1,2
Process Indicator - Class 3

- Wires are not at the base of the terminal, or in contact with the previously installed wire.

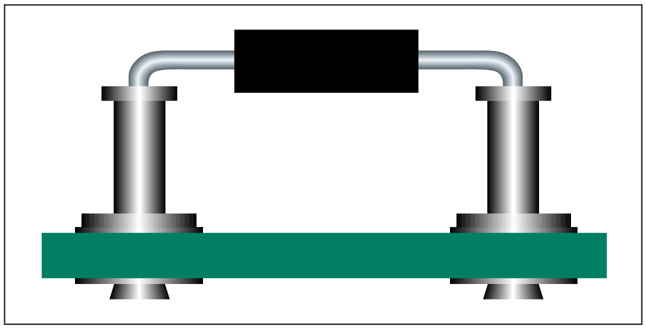

Figure 5-113

Acceptable - Class 1,2,3

- Calibration parts are mounted to the tops of terminals (hollow terminal).

5.6 Insulation

5.6.1 Insulation – Clearance

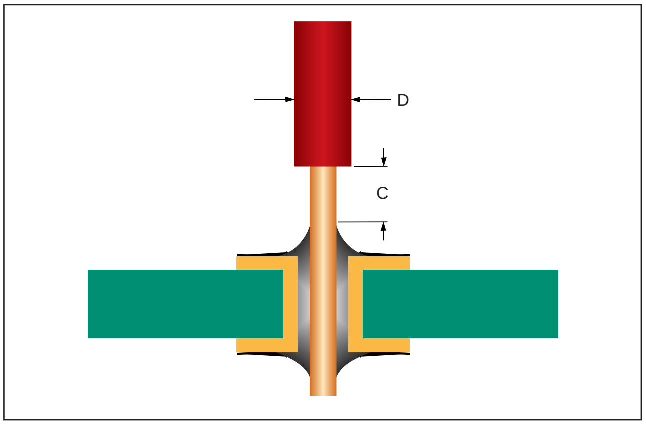

Figure 5-114

Target - Class 1,2,3

- There is an insulation clearance (C) of one diameter (D) between the end of the insulation and the top of the solder fillet.

Note: Solder is shown for visual clarification.

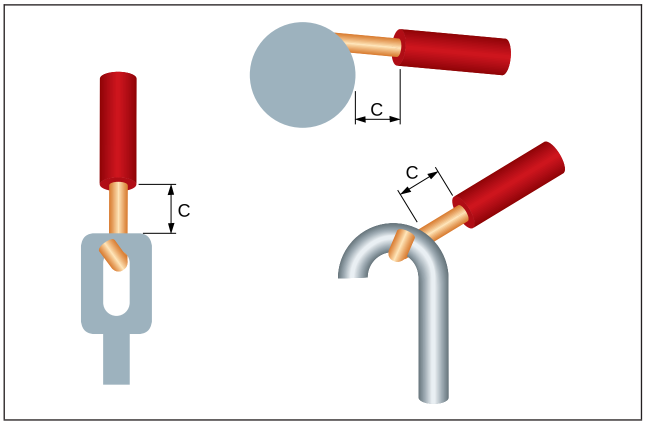

Figure 5-115

Acceptable - Class 1,2,3

- The insulation clearance (C) is two wire diameters or less including insulation or 1.5 mm [0.0591 in] (whichever is greater).
- Insulation clearance (C) does not permit shorting to adjacent conductors.

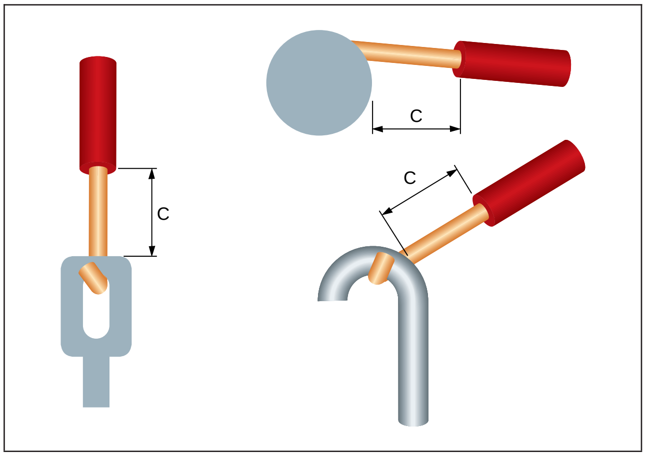

Figure 5-116

Process Indicator - Class 2,3

- The insulation clearance (C) is greater than two wire diameters including insulation or 1.5 mm [0.0591 in], whichever is greater.

Defect - Class 1,2,3

- Insulation clearance (C) permits shorting to adjacent conductors.

5.6.2 Insulation – Damage

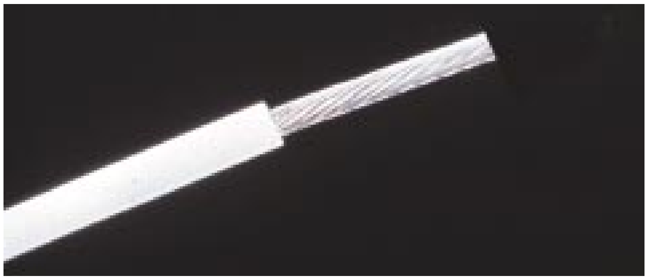

Figure 5-117

Target - Class 1,2,3

- Insulation has been trimmed neatly with no signs of pinching, pulling, fraying, discoloration, charring or burning.

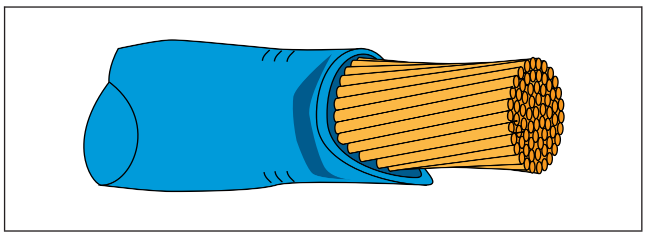

Figure 5-118

Acceptable - Class 1,2,3

- A slight, uniform impression in the insulation from the gripping of mechanical strippers.
- Thermally stripped insulation shows slight discoloration.
- Chemical solutions, paste, and creams used to strip solid wires do not cause degradation to the wire.

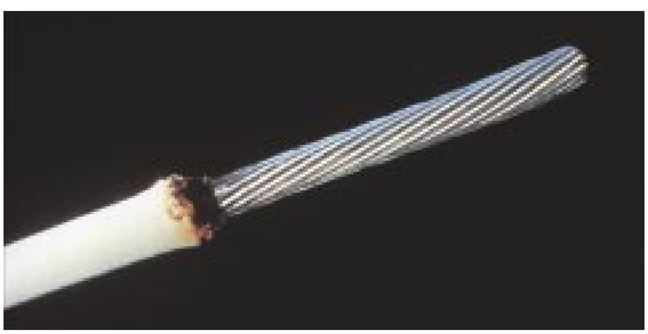

Figure 5-119

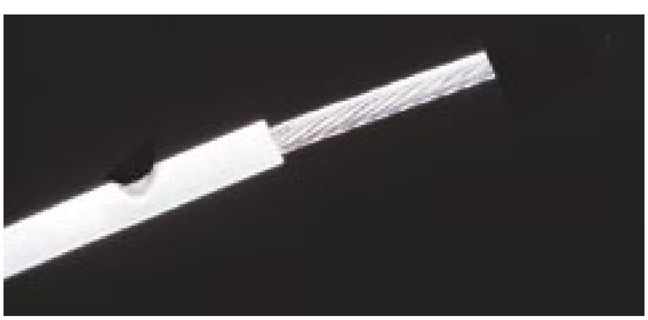

Figure 5-120

Defect Class - 1,2,3

- Charred insulation.
- Insulation damaged exposing wire (except as noted in 11.1.9).
- Solderability degraded by chemical stripping operation.

5.6.3 Insulation – Flexible Sleeve

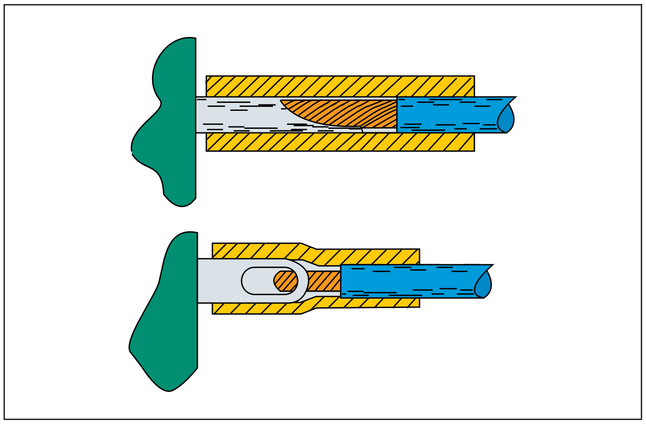

Figure 5-121

Acceptable - Class 1,2,3

- The sleeving used to insulate the terminal/wire fits snugly.
- The sleeving overlaps the wire insulation by a minimum of 6.0 mm [0.236] or two OD of the wire whichever is larger.
- The exposed terminal above the board surface is less than 50% the terminal diameter (or width) from the board.

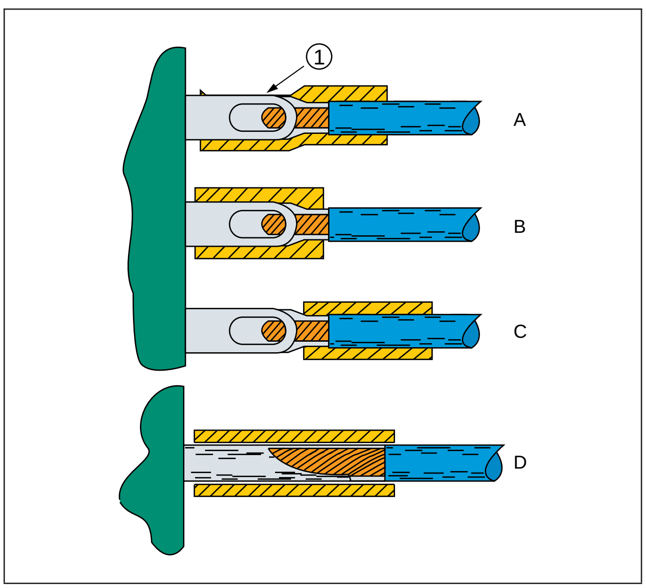

Figure 5-122
1. Split sleeving

Acceptable - Class 1 (if no danger of shorting)
Defect - Class 2,3

A. The sleeve has split and/or exposes the terminal above the 50% width distance from the board allowed.
B. The sleeving does not overlap the wire insulation sufficiently.
C. Insufficient sleeving overlap on terminal.
D. The sleeve is loose on the terminal (might slide or vibrate off, exposing more than the allowed amount of conductor/terminal).

5.7 Conductor

Applies to multistranded wires. (See 5.4.1 for lead damage requirements applicable to single strand wires.)

5.7.1 Conductor – Deformation

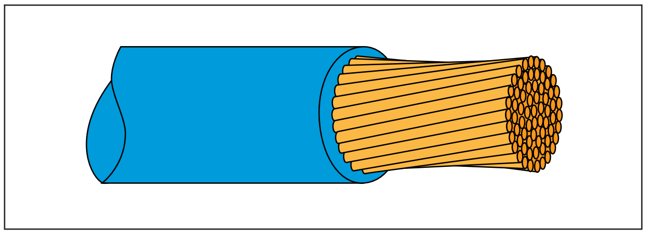

Figure 5-123

Target - Class 1,2,3

- Strands are not scraped, flattened, untwisted, buckled, kinked or otherwise deformed.

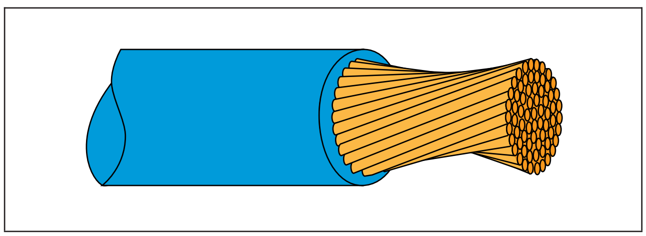

Figure 5-124

Acceptable - Class 1,2,3

- Where strands were straightened during the insulation removal, they have been re-twisted to the original lay of the wire.

5.7.1 Conductor – Deformation (cont.)

Figure 5-125

Acceptable - Class 1,2,3

- Birdcaging (spreading of strands) does not exceed extruded insulation diameter.

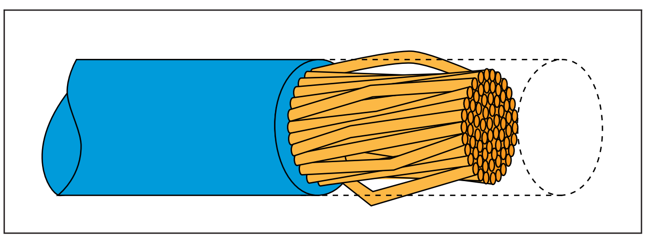

Figure 5-126

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Birdcaging has caused wire strands to extend beyond the insulation diameter.
- The general spiral lay of the strands has not been maintained.

5.7.2 Conductor – Damage

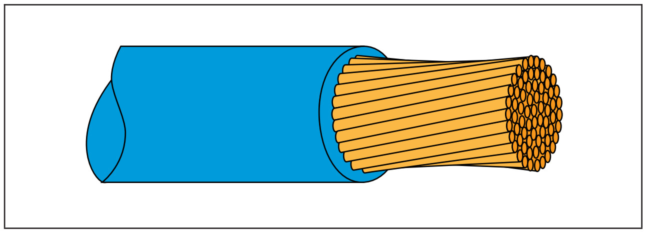

Figure 5-127

Target - Class 1,2,3

- Wires are not scraped, nicked, cut, scored, or otherwise damaged.

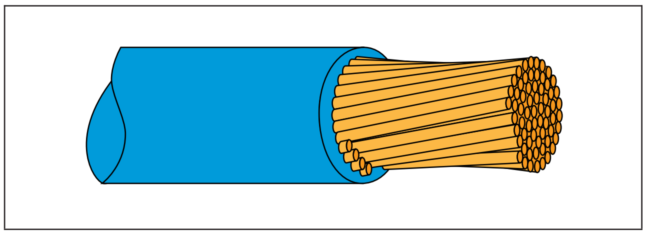

Figure 5-128

Acceptable - Class 1
Process Indicator - Class 2,3

- Strands cut, broken, or severed as a result of insulation stripping if the number of damaged or broken strands in a single wire does not exceed the limits in Table 5-4.

Defect - Class 1,2,3

- The number of damaged (nicked or broken) strands in a single wire exceeds the limits in Table 5-4.

Table 5-4 Strand Damage

Number or Strands	Maximum Allowable Damaged Strands[1]
Less than 7	0
7-15	1
16-18	2
19-25	3
26-36	4
37-40	5
41 or more	6

Note 1. No damaged strands for wires used at a potential of 6 kV or greater.

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Soldering Acceptability Requirements

This section establishes the acceptability requirements for soldered connections of all types. Although Class 1, 2 and 3 applications and environments have been considered, the nature of the soldering process may dictate that an acceptable connection will have the same characteristics for all three classes, and an unacceptable connection would be rejected for all three classes.

Where appropriate, the type of soldering process used has been addressed specifically in the criteria description. In any case, the connection criteria applies regardless of which methods of soldering have been utilized, for example:

• Soldering irons.

• Resistance soldering apparatus.

• Induction wave, or drag soldering.

• Reflow soldering.

As an exception to the above, there are specialized soldering processes, (e.g., pin/paste-in-hole, intrusive soldering, etc.) that require the creation of special acceptance criteria other than as stated in this document. The criteria should be based on design, process capability and performance requirements.

This section addresses the following subjects:

6.1 Soldering Acceptability Requirements

The preferred conditions of the solder to metal interface, from the physics of wetting, require low or near zero contact angles.

Wetting cannot be judged by surface appearance; it can only be inferred by the presence of a low or near zero degree contact angle.

A nonwetted condition is normally considered to exist if the solder alloy does not wet parts of the original surface. (See Note at 6.5.2 for additional information.) Normally this implies that the contact angle exceeds 90°. Also see ANSI/J-STD-001.

All target solder connections have from a shiny to a satin luster, generally smooth appearance and exhibit wetting as exemplified by a concave meniscus between the objects being soldered. High temperature solders may have a dull appearance. Touch-up (rework) of soldered connections is performed with discretion to avoid causing additional problems, and to produce results that exhibit the acceptability criteria of the applicable class.

6.1 Soldering Acceptability Requirements (cont.)

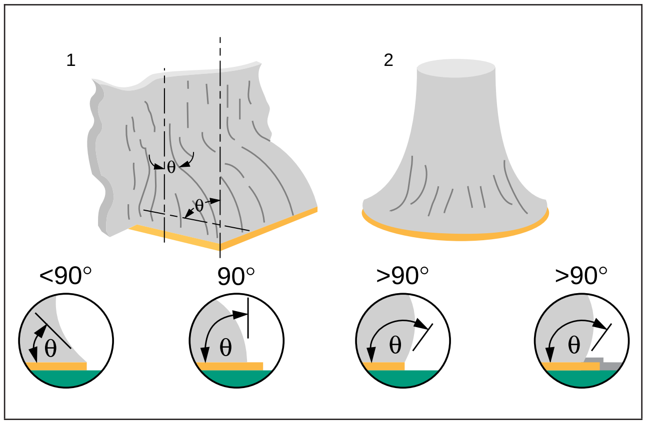

Figure 6-1

Target - Class 1,2,3

- The solder fillet appears generally smooth and exhibits good wetting of the solder to the parts being joined. The outline of the parts is easily determined. The solder at the part being joined creates a feathered edge. The fillet is concave in shape.

Acceptable - Class 1,2,3

- There are solder alloy compositions, lead or printed board platings and special soldering processes, (i.e., slow cooling with large mass PWBs) that may produce dull matte, gray, or grainy appearing solders that are normal for the material or process involved. These solder connections are acceptable.
- The acceptable solder connection must indicate evidence of wetting and adherence when the solder blends to the soldered surface, forming a contact angle of 90° or less, except when the quantity of solder results in a contour which extends over the edge of the land or solder resist.

Note: Blowholes, pinholes, etc., are process indicators providing that the solder connection meets the minimum requirements of Table 6-2. See 6.5.4.

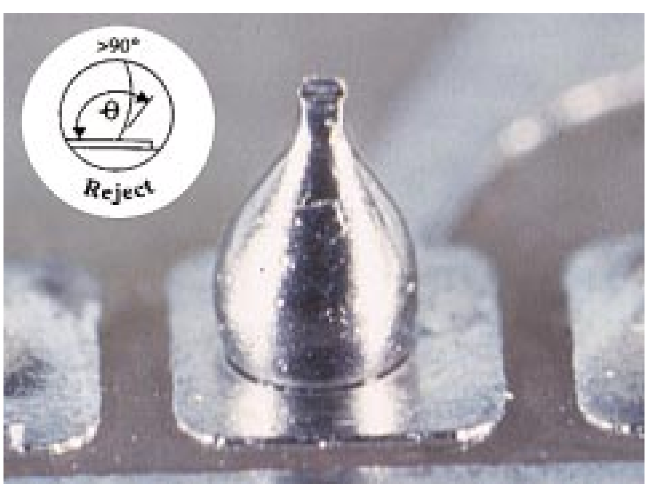

Figure 6-2

Defect - Class 1,2,3

- Nonwetting which results in the solder forming a ball or bead on the surface, much as water beads form on a waxed surface. The fillet will be convex; no feathered edge apparent.
- Disturbed solder connection.
- Cold solder connection.

6.2 Lead Protrusion

Lead protrusion should not allow a possibility of violating minimum electrical spacing, damage to soldered connections due to lead deflection, or penetration of static protective packaging during subsequent handling or operating environments.

Note: High frequency applications may require more precise control of lead extensions to prevent violation of functional design considerations.

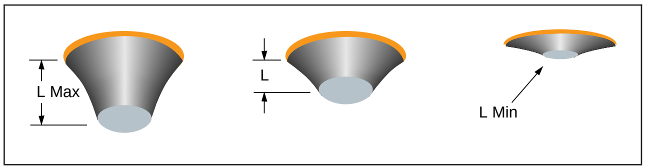

Figure 6-3

Acceptable - Class 1,2,3

- The leads protrude beyond the land within the specified minimum and maximum (L) of Table 6-1, provided there is no danger of violating minimum electrical clearance.

Process Indicator - Class 2 (Supported Hole)
Defect - Class 3 (Supported Hole)

- Lead protrusion does not meet the requirements of Table 6-1.

Defect - Class 1,2,3 (Supported Hole)

- Lead protrusion violates minimum electrical clearance.

Process Indicator - Class 2 (Unsupported Hole)
Defect - Class 3 (Unsupported Hole)

- Lead protrusion is inadequate to permit lead clinching a minimum of 45°.

Defect - Class 1,2,3 (Unsupported Hole)

- Lead protrusion is less than 0.5 mm [0.020 in].
- Lead protrusion violates minimum electrical clearance.

Table 6-1 Lead Protrusion

	Class 1	Class 2	Class 3
(L) min.[1]	End is discernible in solder[2]		
(L) max.	No danger of shorts	2.3 mm [0.0906 in]	1.5 mm [0.0591 in]

Note 1. For single-sided boards, lead or wire protrusion (L), is at least 0.5 mm [0.020 in] for Class 1 and 2. There must be sufficient protrusion for Class 3 to clinch.

Note 2. For plated-through hole boards greater than 2.3 mm [0.0906 in] thick, components with pre-established lead lengths, (DIPs, sockets), lead protrusion may not be discernible.

6.3 Plated-Through Holes (PTH) (Supported Holes)

Table 6-2 Plated-Through Holes with Component Leads, Minimum Acceptable Conditions [1]

Criteria	Class 1	Class 2	Class 3
A. Circumferential wetting on primary side (solder destination side) of lead and barrel	Not Specified	180°	270°
B. Vertical fill of solder [2]	Not Specified	75%	75%
C. Circumferential fillet and wetting on secondary side (solder source side) of lead and barrel [3]	270°	270°	330°
D. Percentage of land area covered with wetted solder on solder primary side (destination side)	0	0	0
E. Percentage of land area covered with wetted solder on secondary side (solder source side) [4]	75%	75%	75%

Note 1. Wetted solder refers to solder applied by the solder process.
Note 2. The 25% unfilled height includes both source and destination side depressions.
Note 3. Also applies to lead and land of unsupported holes.
Note 4. Also applies to unsupported holes.

Defect - Class 1,2,3

- Solder connection is not in compliance with Table 6-2.

6.3.1 PTH – Vertical Fill of Hole

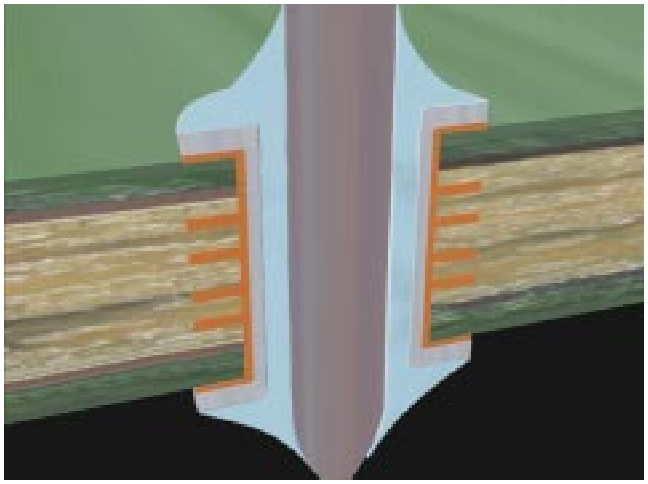

Figure 6-4

Target - Class 1,2,3

• There is 100% fill.

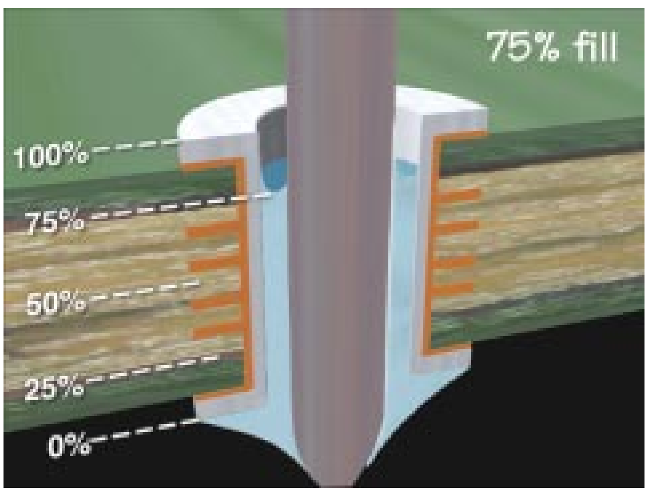

Figure 6-5

Acceptable - Class 1,2,3

• Minimum 75% fill. A total maximum of 25% depression, including both secondary and primary sides is permitted.

Defect - Class 2,3

• Vertical fill of hole is less than 75%.

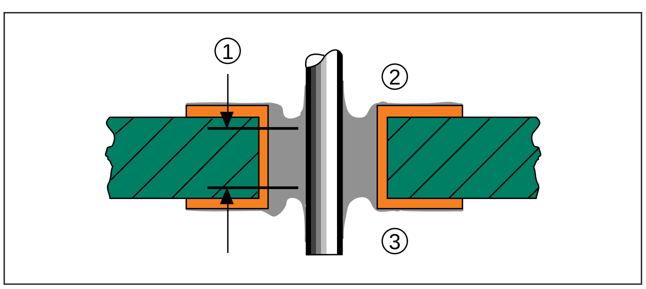

Figure 6-6

1. Vertical fill meets requirements of Table 6-2
2. Solder destination side
3. Solder source side

6.3.1 PTH – Vertical Fill of Hole (cont.)

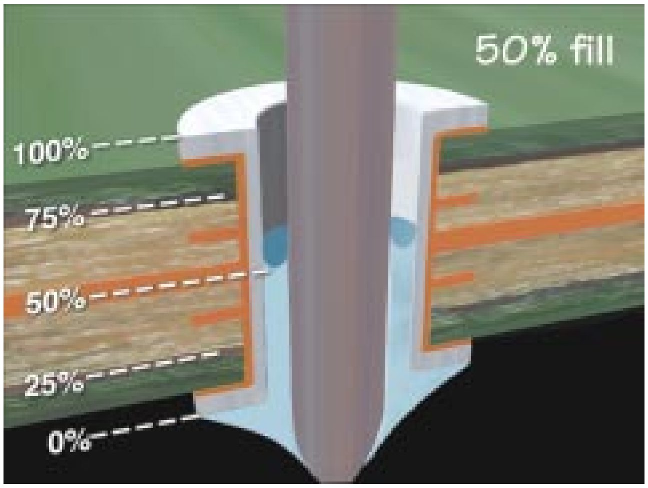

Figure 6-7

Not Specified - Class 1
Acceptable - Class 2
Defect - Class 3

- As an exception to fill requirements of Table 6-2 on PTHs with thermal planes or conductor planes that act as heat sinks, a 50% vertical fill of solder is permitted, but with solder extending 360° around the lead with 100% wetting from barrel walls to lead on the secondary side, and surrounding PTHs meet requirements of Table 6-2.

Note: Less than 100% solder fill may not be acceptable in some applications, e.g., thermal shock. The user is responsible for identifying these situations to the manufacturer.

6.3.2 PTH – Circumferential Wetting – Primary Side

6.3.2.1 PTH – Circumferential Wetting – Primary Side – Lead and Barrel

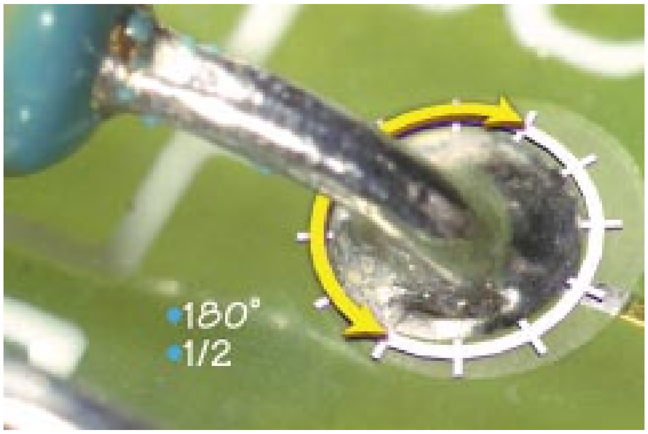

Figure 6-8

Not Specified - Class 1
Acceptable - Class 2

• Minimum 180° wetting present on lead and barrel.

Defect - Class 2

• Less than 180° wetting on lead or barrel.

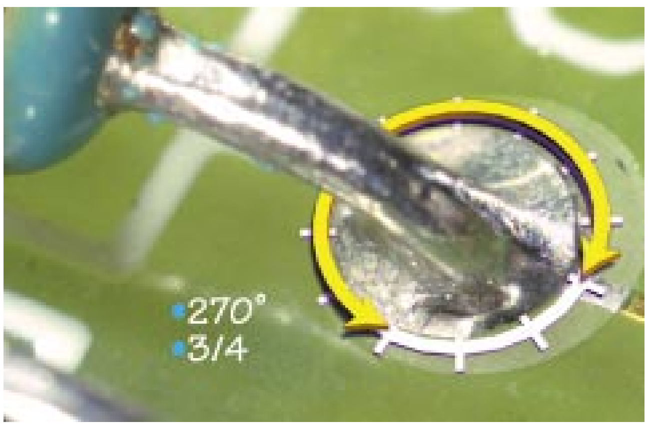

Figure 6-9

Acceptable - Class 3

• Minimum 270° wetting present on lead and barrel.

Defect - Class 3

• Less than 270° wetting on lead or barrel.

6.3.2.2 PTH – Land Area Coverage – Primary Side

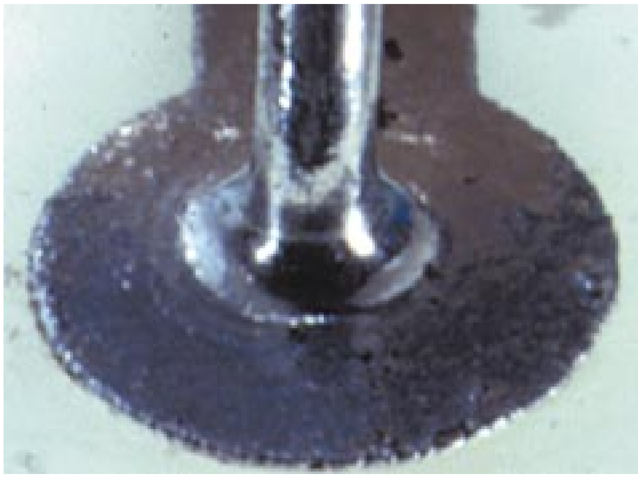

Figure 6-10

Acceptable - Class 1,2,3

- The land area does not need to be wetted with solder on the primary side.

6.3.3 PTH – Circumferential Wetting – Secondary Side (PTH and Unsupported Holes)

Applies to both PTH and unsupported holes.

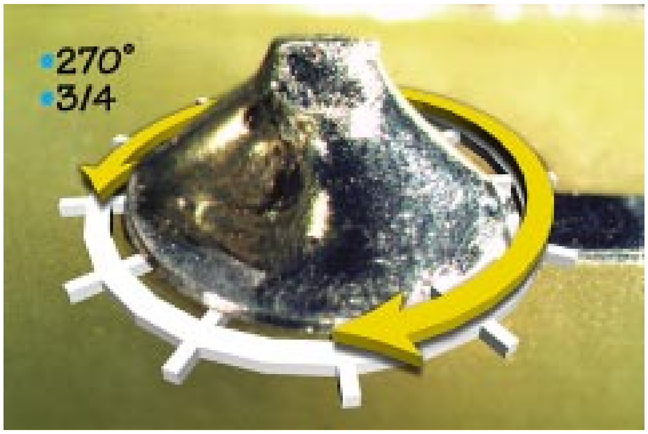

Figure 6-11

Acceptable - Class 1,2

- Minimum 270° fillet and wetting (lead, barrel and termination area).

Acceptable - Class 3

- Minimum 330° fillet and wetting (lead, barrel and termination area). (Not Shown.)

Figure 6-12

Acceptable - Class 1,2,3

- Minimum 75% of land area covered with wetted solder on the secondary side.

6.3.4 PTH Mounted Components

6.3.4.1 PTH Mounted Components - Solder Conditions

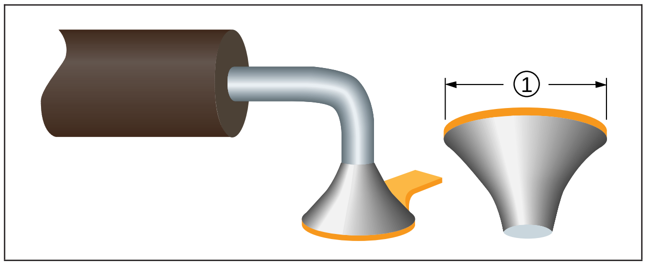

Figure 6-13
1. Land area

Target - Class 1,2,3

- No void areas or surface imperfections.
- Lead and land are well wetted.
- Lead is discernible.
- 100% solder fillet around lead.
- Solder covers lead and feathers out to a thin edge on land/conductor.

Figure 6-14

Acceptable - Class 1,2,3

- Fillet is concave, good wetting action and lead is discernible in the solder.

6.3.4.1 PTH Mounted Components - Solder Conditions (cont.)

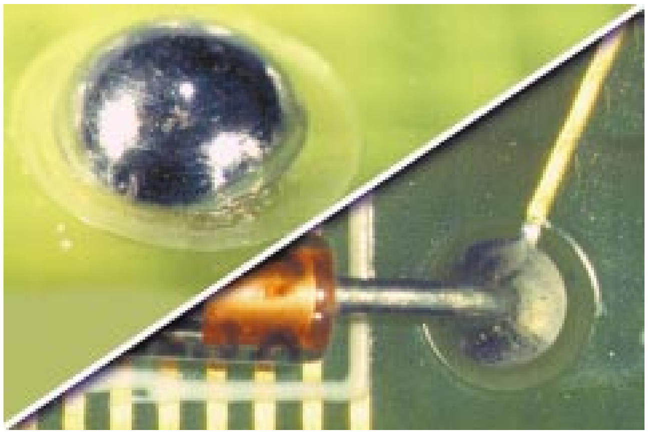

Figure 6-15

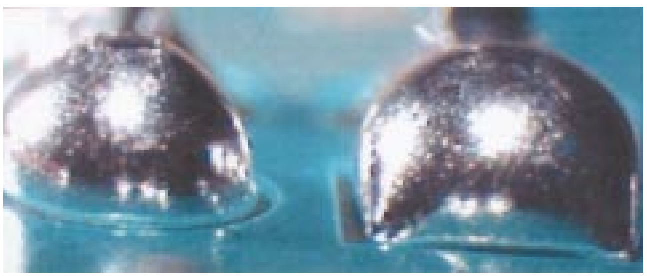

Figure 6-16

Acceptable - Class 1
Process Indicator - Class 2,3

• Fillet convex, lead not discernible due to excess solder, providing visual evidence of the lead in the hole can be determined on the primary side.

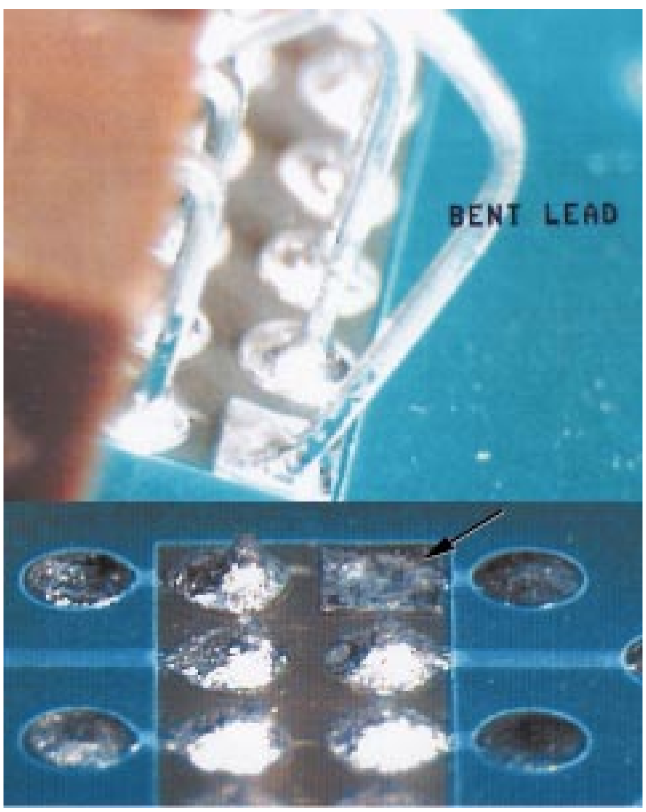

Figure 6-17

Defect - Class 1,2,3

• Lead not discernible due to bent lead.

6.3.4.2 PTH Mounted Components – Solder in Lead Bend

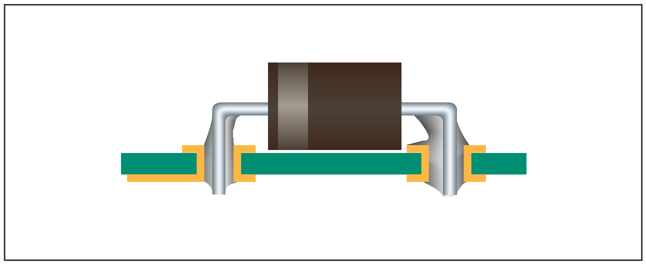

Figure 6-18

Figure 6-19

Acceptable - Class 1,2,3

Solder in lead bend area does not contact the component body.

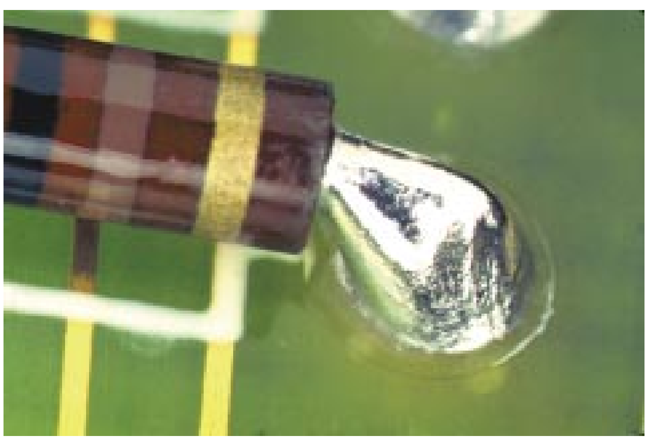

Figure 6-20

Defect - Class 1,2,3

- Solder in bend area comes in contact with the component body or end seal.

6.3.4.3 PTH – Meniscus in Solder

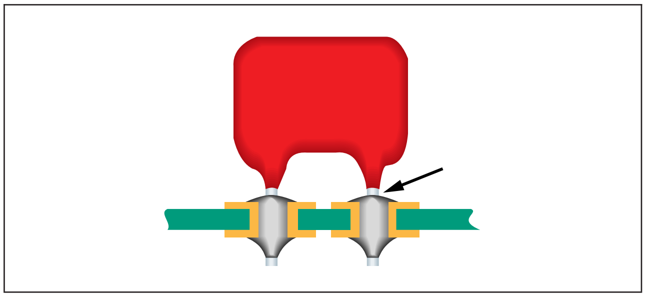

Figure 6-21

Target - Class 1,2,3

- Coated or sealed components: There is discernible clearance above the solder connection.

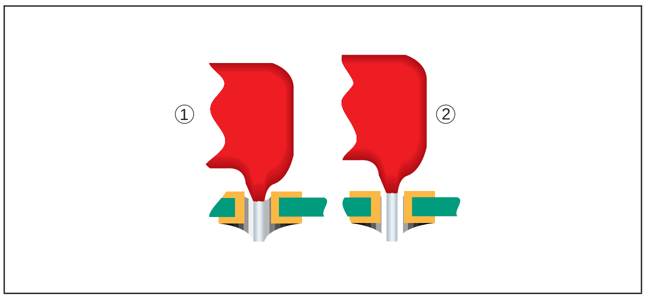

Figure 6-22
1. Class 1,2
2. Class 3

Acceptable - Class 1,2

- As an exception to Table 6-2, components with a coating meniscus can be mounted with the meniscus into the solder provided:
  - 360° wetting on secondary side is discernible.
  - Lead coating meniscus is not discernible within connection on secondary side.

Acceptable - Class 3

- Meets the requirements of Table 6-2.

Defect - Class 1,2,3

- Does not exhibit good wetting on secondary side.

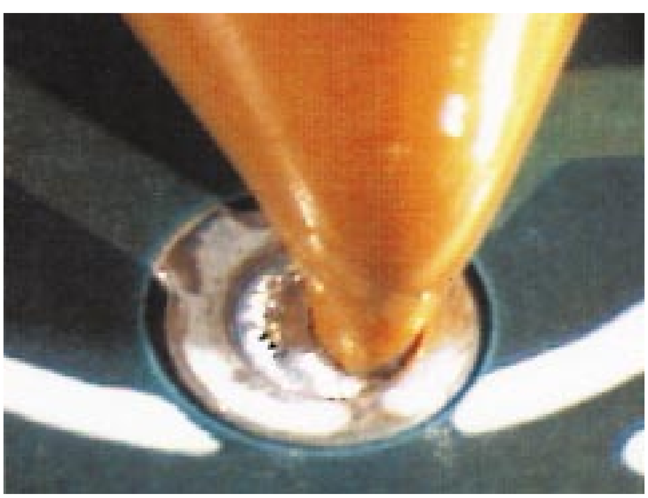

Figure 6-23

Defect - Class 3

- Does not meet requirements of Table 6-2.

Note: When required for certain applications, meniscus on the components are to be controlled to ensure that, with components fully seated, the meniscus on the leads does not enter the plated-through holes of the assembly. (Example: high frequency applications, very thin PWBs.)

6.3.5 PTH – Coated Wire Insulation in Solder

These requirements apply when the solder connection meets the minimum requirements of Table 6-2. See 6.7 for extruded insulation requirements.

This section applies to coatings that may extend into the connection during soldering operations, provided the material is not corrosive.

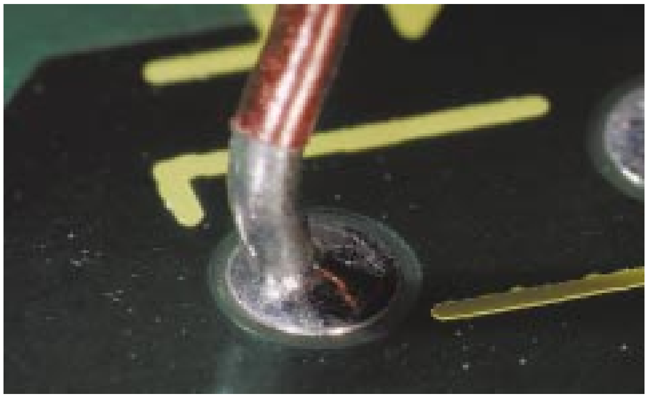

Figure 6-24

Target - Class 1,2,3

- Clearance of one wire diameter between solder fillet and insulation.

Figure 6-25

Acceptable - Class 1,2
Process Indicator - Class 3

- Coating is entering solder connection on primary side but exhibits all around good wetting on secondary side.
- Coating is not discernible on secondary side.

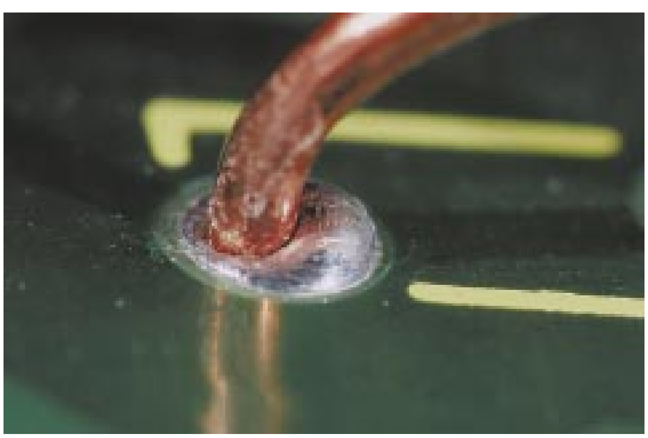

Figure 6-26

Defect - Class 1,2,3

- Solder connection exhibits poor wetting and does not meet the minimum requirements of Table 6-2.
- Coating is discernible on secondary side.

6.3.6 PTH – Interfacial Connection Without Lead – Vias

Plated-through holes used for interfacial connection not exposed to solder because of permanent or temporary masks need not be filled with solder. Plated-through holes or vias without leads, after exposure to wave, dip or drag soldering equipment are to meet these acceptability requirements.

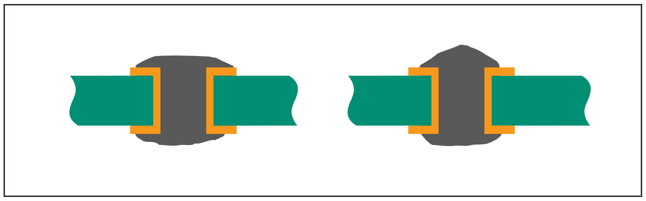

Figure 6-27

Target - Class 1,2,3

- Holes are completely filled with solder.
- The tops of lands show good wetting.

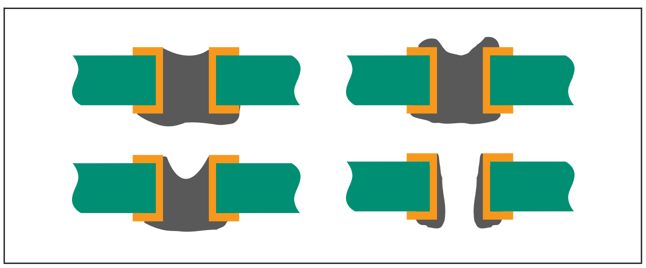

Figure 6-28

Acceptable - Class 1,2,3

- Sides of holes are wetted with solder.

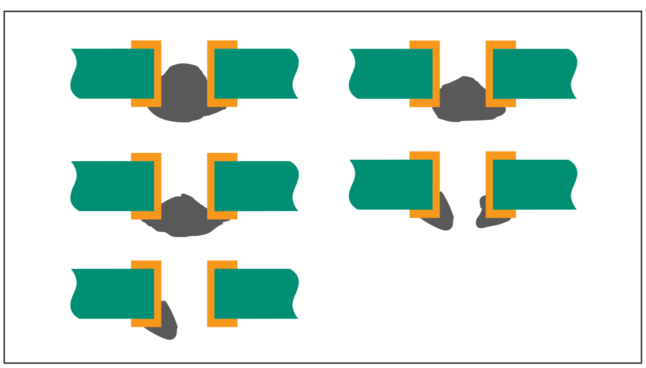

Figure 6-29

Acceptable - Class 1
Process Indicator - Class 2,3

- Solder has not wetted side of holes.

Note: There is no defect condition for this.

Note: Solder capped PTHs have the possibility of entrapping contaminants which are difficult to remove if cleaning is required.

6.4 Unsupported Holes

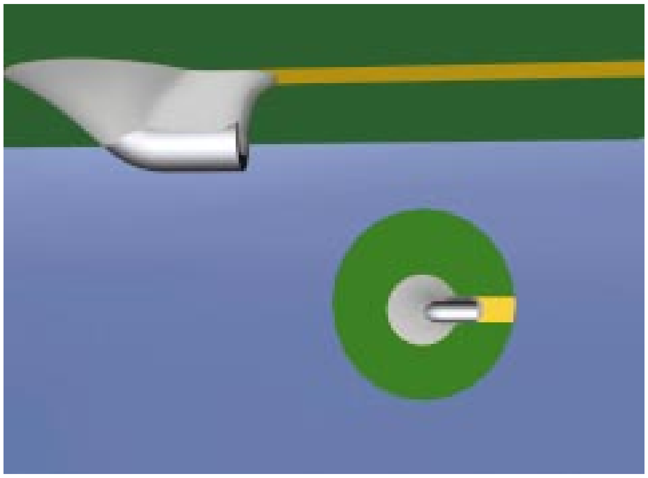

Figure 6-30

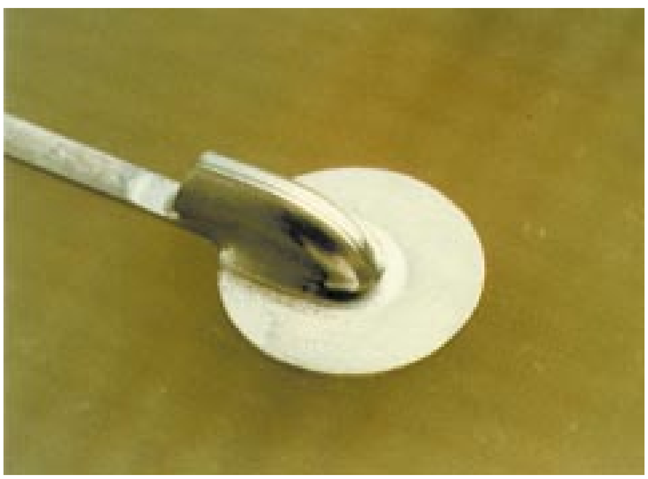

Figure 6-31

Target - Class 1,2,3

- Solder termination, (land and lead), covered with wetted solder and outline of lead discernible in the solder fillet.
- No void areas or surface imperfections.
- Lead and land are well wetted.
- Lead is clinched.
- 100% solder fillet around lead.

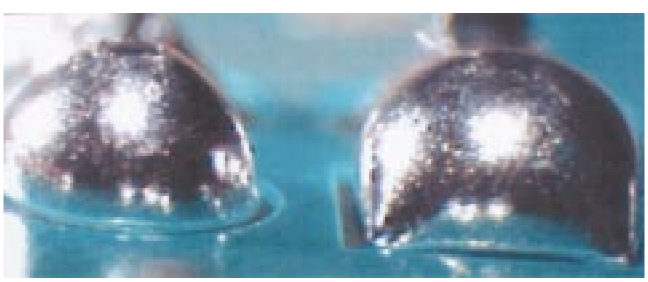

Figure 6-32

Acceptable - Class 1
Process Indicator - Class 2,3

- Lead not discernible due to excess solder.
- Must be visual evidence on primary side that the lead is in the hole.

Defect - Class 3

- Leads not clinched.

6.4 Unsupported Holes (cont.)

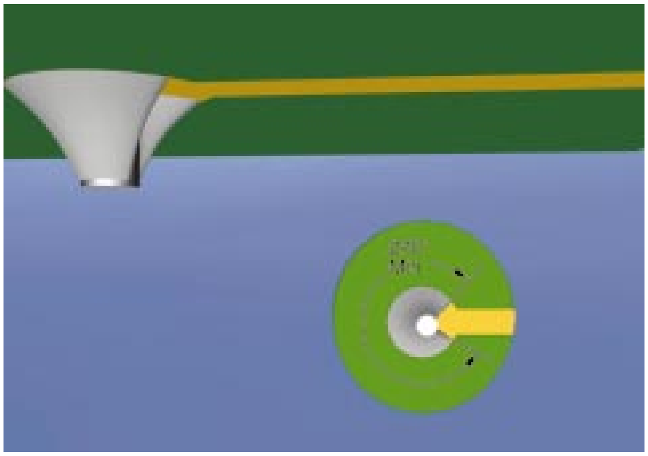

Figure 6-33

Acceptable - Class 1,2

- Solder coverage meets requirements of Table 6-2 C and E.

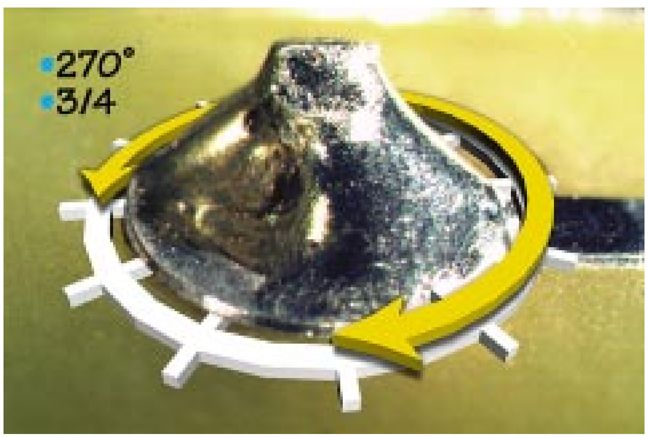

Figure 6-34

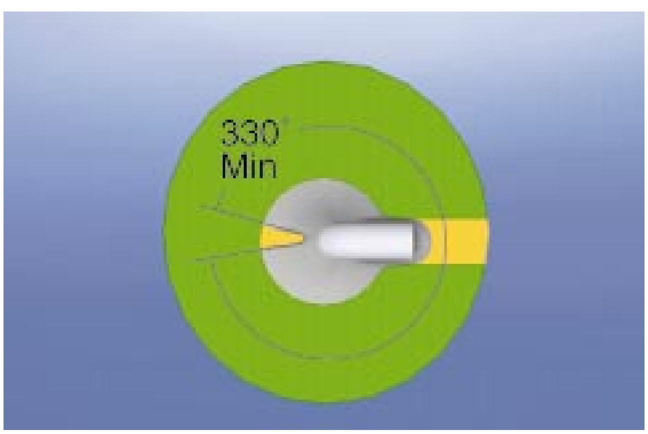

Figure 6-35

Acceptable - Class 3

- Minimum 330° circumferential fillet and wetting.
- Lead is wetted in the clinched area.

6.4 Unsupported Holes (cont.)

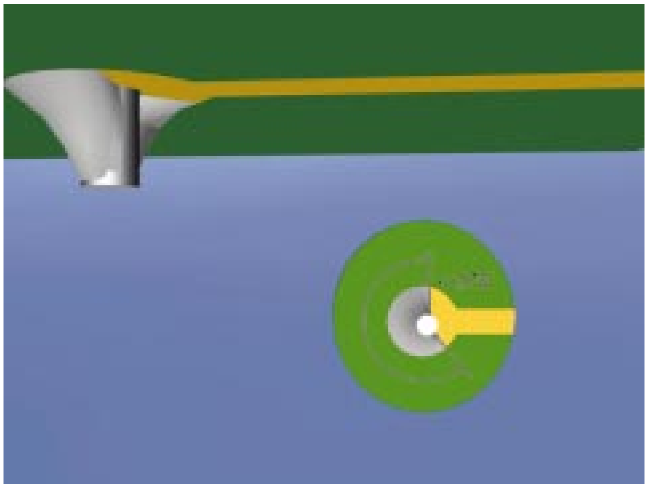

Figure 6-36

Defect - Class 1,2

- Solder connection of straight through termination does not meet minimum 270° circumferential fillet or wetting.
- Less than 75% pad coverage.

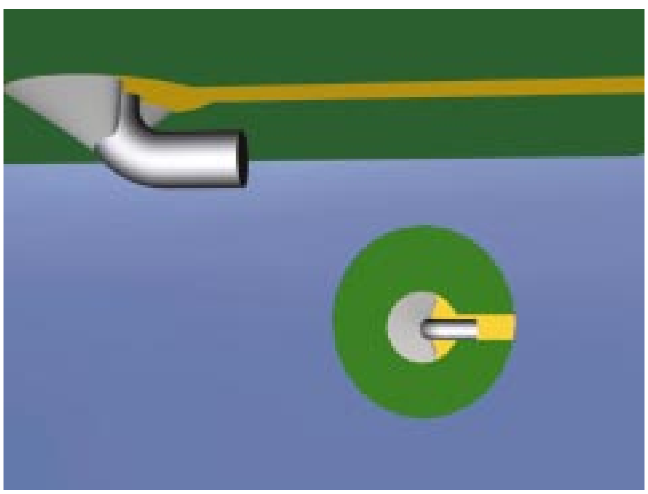

Figure 6-37

Defect - Class 3

- Solder connection does not meet 330° circumferential fillet or wetting.
- Lead not wetted in clinched area.
- Less than 75% pad coverage.

6.5 Other

The conditions in this section are applicable to both supported and unsupported connections.

6.5.1 Lead Cutting After Soldering

The following criterion applies to printed board assemblies where the secondary side has had connections trimmed after soldering. Leads may be trimmed after soldering provided the cutters do not damage the component or solder connection due to physical shock. When lead cutting is performed after soldering, the solder terminations are to be visually inspected at 10X to ensure that the original solder connection has not been damaged, (e.g., fractured or deformed). As an alternative to visual inspection, the solder connections may be reflowed. If the solder connection is reflowed this is considered part of the soldering process and is not to be considered rework. This requirement is not intended to apply to components which are designed such that a portion of the lead is intended to be removed after soldering, (e.g., break away tie bars).

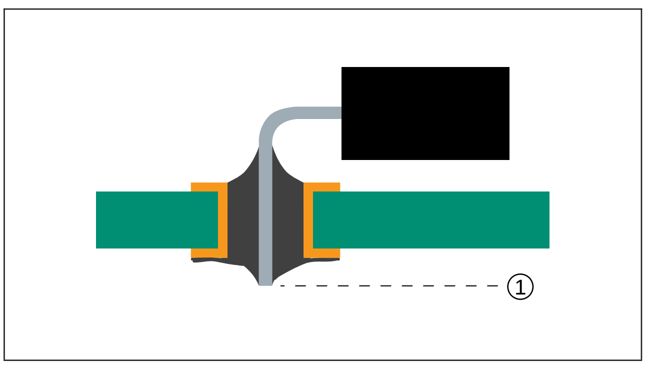

Figure 6-38
1. Lead protrusion

Acceptable - Class 1,2,3

- No fractures between lead and solder.
- Lead protrusion within specification.

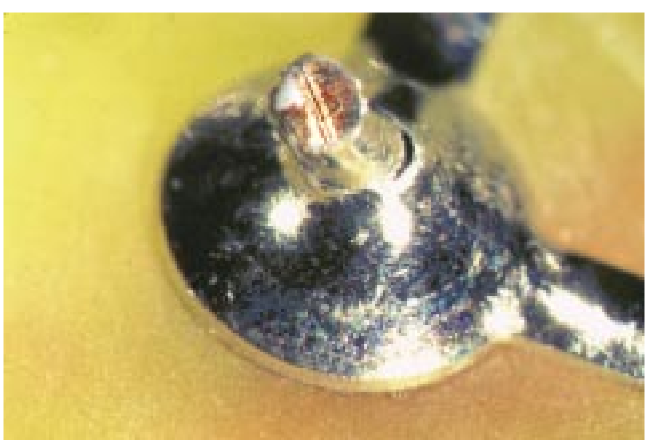

Figure 6-39

Defect - Class 1,2,3

- Evidence of fracture between lead and solder fillet.

6.5.2 Exposed Basis Metal

Surface mount ICs, organic solderability preservative (OSP) coated PWBs, leaded components, sides of land patterns, conductors, and use of liquid photoimageable solder resist, can have exposed basis metal per original designs.

Note: Printed wiring boards and conductors with alternative (OSP) finishes may exhibit solder wetting only to specific areas where solder is intended. Exposed base metal in unsoldered areas should be considered normal under these circumstances, provided the achieved wetting characteristics of the intended solder connection areas are acceptable.

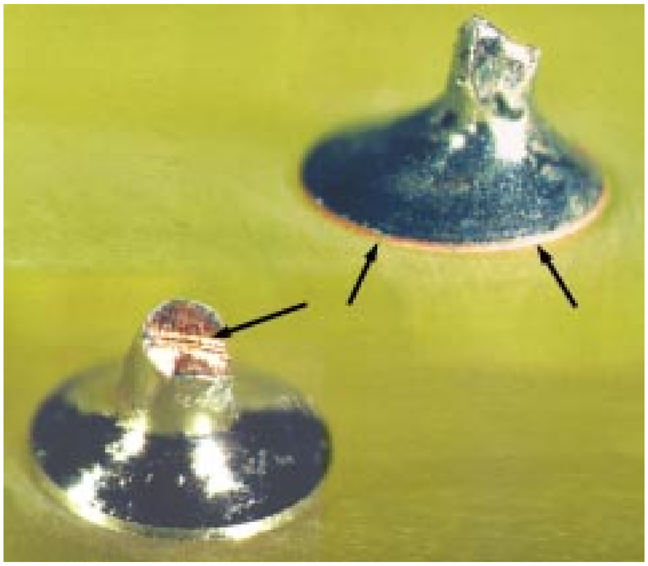

Figure 6-40

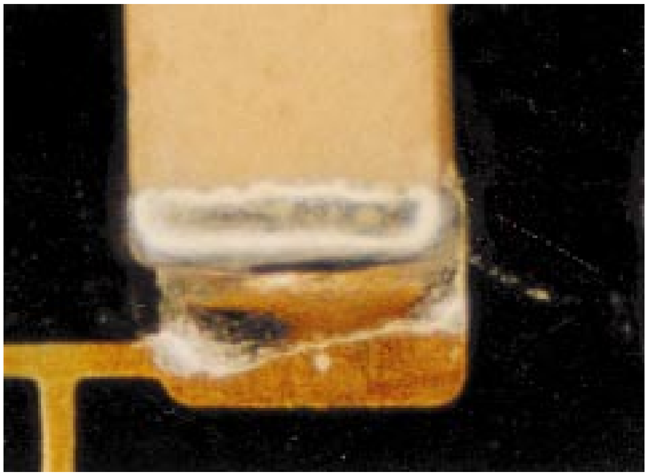

Figure 6-41

Acceptable - Class 1,2,3

- Exposed copper on vertical conductor edges.
- Exposed basis metal at ends of component leads.

6.5.2 Exposed Basis Metal (cont.)

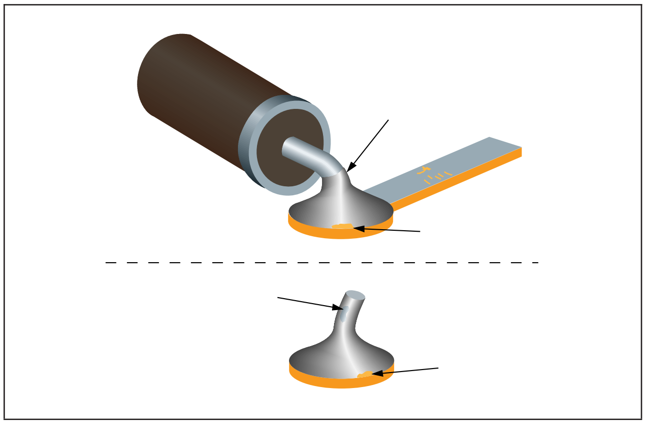

Figure 6-42

Acceptable - Class 1
Process Indicator - Class 2,3

- Exposed basis metal on component leads, conductors or land surfaces from nicks, scratches, or other conditions cannot exceed the requirements of 5.4.1 for leads and 10.7 for conductors and lands.

6.5.3 Excess Solder

6.5.3.1 Excess Solder – Solder Balls/Splashes

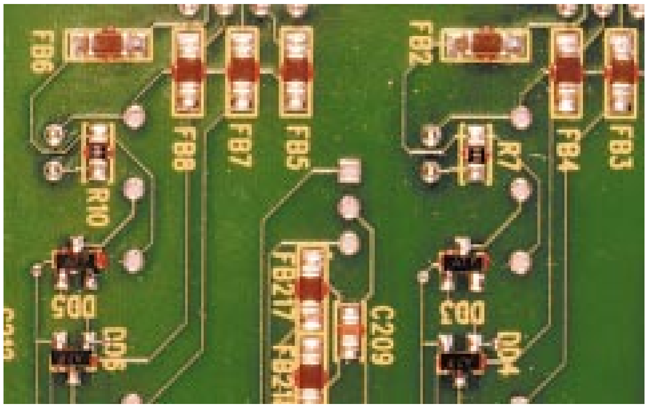

Figure 6-43

Target - Class 1,2,3

- No evidence of solder balls on the printed wiring assembly.

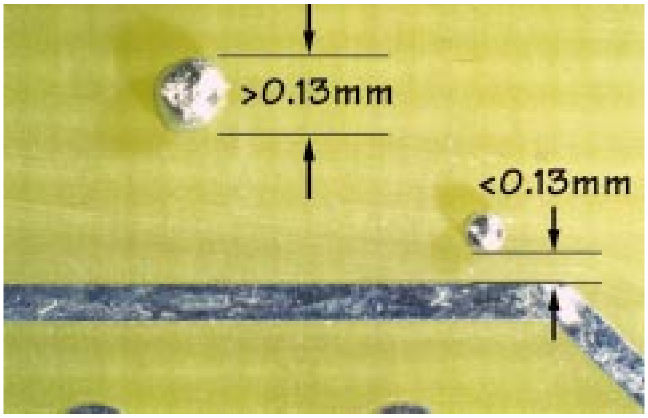

Figure 6-44

Acceptable - Class 1
Process Indicator - Class 2,3

- Entrapped or encapsulated solder balls that are within 0.13 mm [0.00512 in] of lands or conductors, or exceed 0.13 mm [0.00512 in] in diameter.
- More than five solder balls/splashes (0.13 mm [0.00512 in] or less) per 600 mm^2 [0.93 in^2].

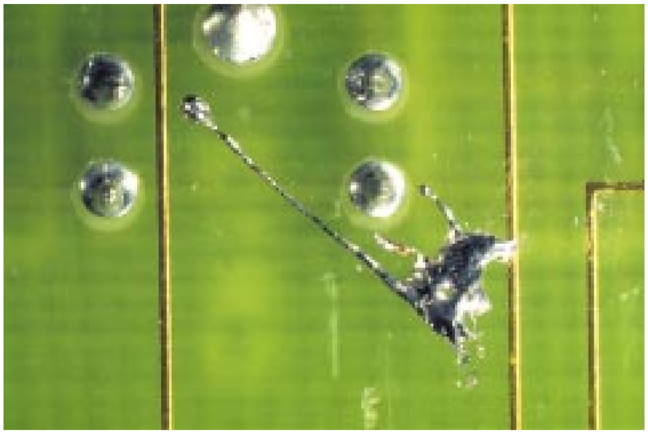

Figure 6-45

Defect - Class 1,2,3

- Solder balls/splashes violate minimum electrical clearance.
- Solder balls/splashes not entrapped or encapsulated (e.g., no-clean residue, conformal coating), or not attached to a metal surface.

Note: Entrapped/encapsulated/attached is intended to mean normal service environment of the product will not cause a solder ball to become dislodged.

6.5.3.2 Excess Solder – Solder Bridging

Figure 6-46

Defect - Class 1,2,3

- Solder has bridged to adjacent noncommon conductor or component.

6.5.3.3 Excess Solder – Solder Webbing

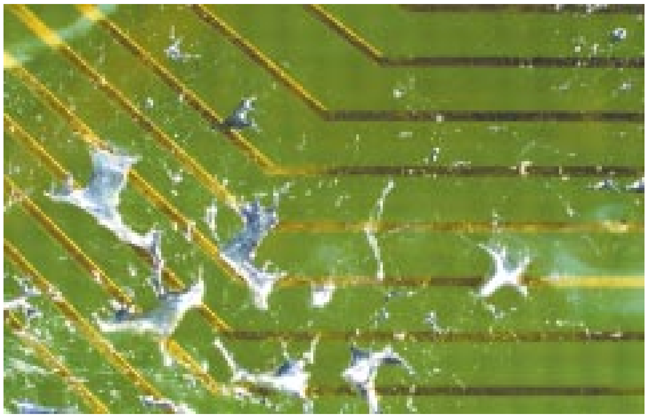

Figure 6-47

Defect - Class 1,2,3

- Solder webbing.

6.5.4 Pin Holes/Blowholes

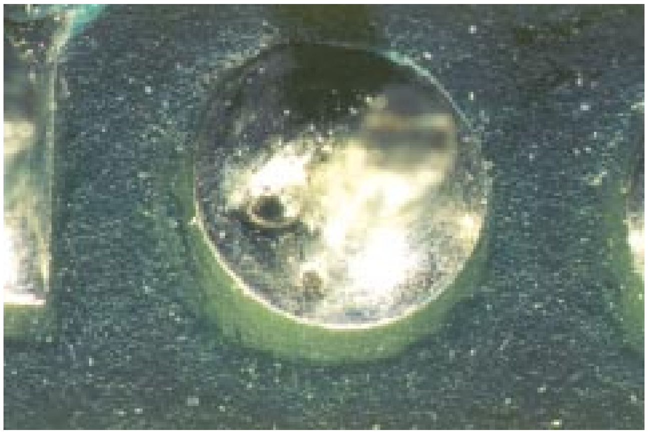

Figure 6-48

Acceptable - Class 1
Process Indicator - Class 2,3

- Blowholes, pinholes, voids, etc., providing that the solder connection meets the minimum requirements of Table 6-2.

6.5.5 Solder Projections

Figure 6-49

Defect - Class 1,2,3

- Solder projection violates assembly maximum height requirements or lead protrusion requirements, (Table 6-1), whichever is greater.

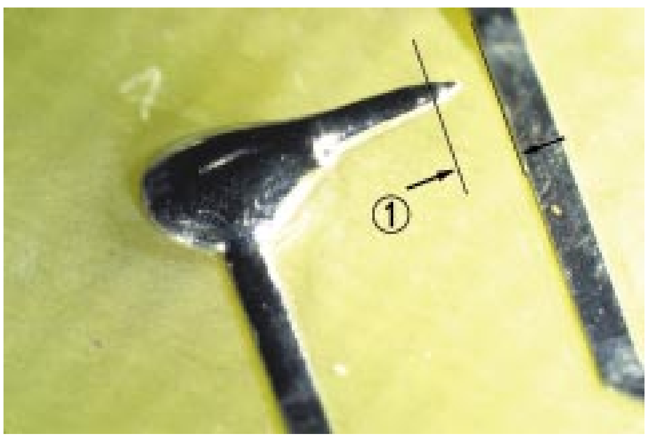

Figure 6-50
1. Electrical clearance

Defect - Class 1,2,3

- Projection violates minimum electrical clearance.

6.5.6 Nonwetting

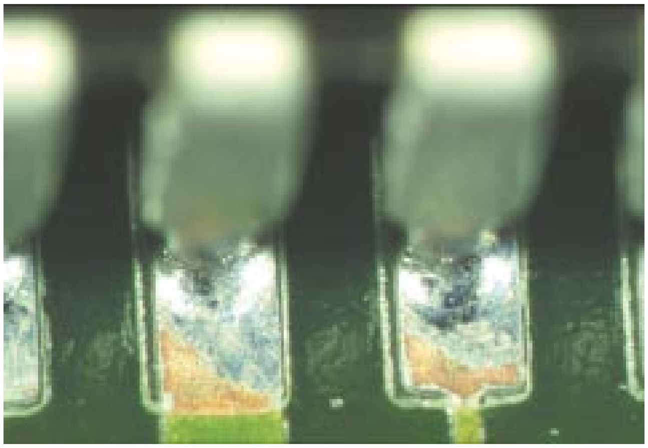

Figure 6-51

Defect - Class 1,2,3

- Nonwetted lead or land if solder is required.

6.6 Terminals

Following are general requirements for all terminals:

Target - Class 1,2,3

- 100% solder fillet around wire/lead and terminal interface (full extent of wrap).
- Solder wets the wire/lead and terminal and forms a discernible fillet feathering out to a smooth edge.
- Wire/lead is clearly discernible in the solder connection.

Acceptable - Class 1,2,3

- Solder fillet at least 75% of the circumference of the wire/lead and terminal interface.
- Wire/lead is barely discernible in solder.

Acceptable - Class 1
Process Indicator - Class 2,3

- Wire/lead not discernible in solder connection.

Defect - Class 1,2,3

- Solder fillet is less than 75% of the circumference of the wire/lead and terminal interface.

6.6.1 Terminals - Bifurcated

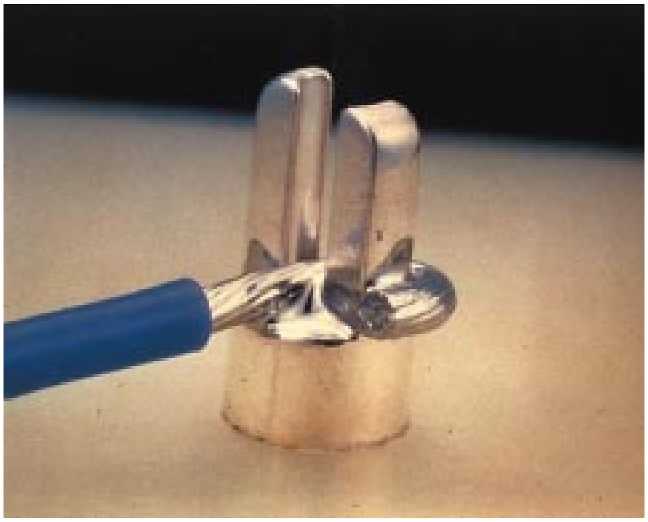

Figure 6-52

Target - Class 1,2,3

- Lead outline is discernible; smooth flow of solder on wire and terminal.
- Solder fillets at all points of wire/lead and terminal interface.

Figure 6-53

Acceptable - Class 1,2,3

- Solder is wetted to at least 75% of the circumference of the wire/lead and terminal interface.

Process Indicator - Class 2
Defect - Class 3

- Less than complete wetting where 90° - 180° bends are allowed.

6.6.2 Terminals – Turret

Figure 6-54

Target - Class 1,2,3

- Lead outline is discernible, smooth flow of solder on wire and terminal.
- Solder fillets at all points of wire/lead and terminal interface.

Figure 6-55

Defect - Class 1,2,3

- Solder fillet is less than 75% of the circumference of the wire and terminal interface.
- Poor wetting.

6.6.3 Terminals – Hook/Pin

Figure 6-56

Target - Class 1,2,3

- Lead outline is discernible; smooth flow of solder on wire and terminal.
- Solder fillets at all points of wire/lead and terminal interface.

Figure 6-57

Acceptable - Class 1,2,3

- Solder fillet joins the wire to the terminal for at least 75% of the wire and terminal contact.

Figure 6-58

Defect - Class 1,2,3

- Does not exhibit a solder fillet joining the wire to the terminal for at least 75% of the wire and terminal contact.
- Solder contact angle greater than 90°.

6.6.4 Terminals – Pierced Tab

Figure 6-59

Target - Class 1,2,3

- Lead outline is discernible; smooth flow of solder on wire and terminal.
- Solder fillets at all points of wire/lead and terminal interface.

Figure 6-60

Acceptable - Class 1,2,3

- Solder fillet joins the wire to the terminal for at least 75% of the wire and terminal contact.

Process Indicator - Class 2
Defect - Class 3

- Less than 100% wetting of terminal/wire interface where 90° bends are allowed.

Figure 6-61

Defect - Class 1,2,3

- Solder dewetted from terminal.
- Solder contact angle greater than 90°.

6.6.5 Terminals – Solder Cups

Applicable to either solid or stranded wire, single or multiple wires.

Figure 6-62

Target - Class 1,2,3

- Solder wets the entire inside of the cup.
- Solder fill is 100%.

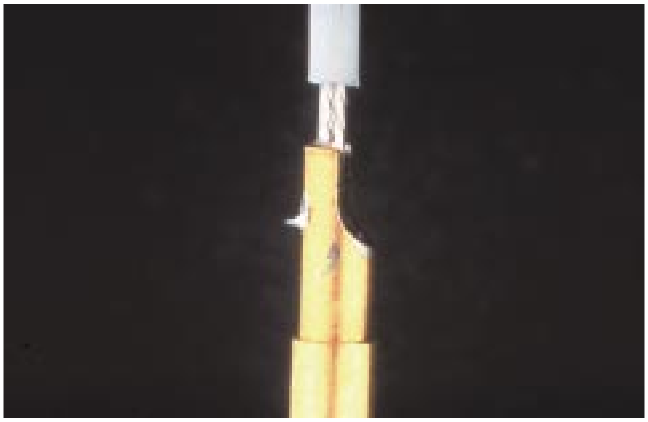

Figure 6-63

Acceptable - Class 1,2,3

- Thin film of solder on the outside of the cup.
- Solder fill greater than 75%.
- Solder buildup on the outside of the cup, as long as it does not affect form, fit and function.

Figure 6-64

Defect - Class 2,3

- Solder vertical fill less than 75%.

6.6.6 Terminals – Flared Flange Hardware

The flange is not split, cracked or otherwise discontinuous to the extent that flux, oils, inks, or other liquid substances utilized for processing the printed board can be entrapped within the mounting hole. After swaging, the area is to be free of circumferential splits or cracks.

The barrel may have solder in it if it is not detrimental to later assembly steps.

The manufactured flange (head) of the eyelet needs to be in full contact with the land area.

Figure 6-65

Target - Class 1,2,3

- Solder around periphery of flange.
- Good filleting of solder around flange.
- Good wetting of flange and terminal area.
- The swaged flange needs to be as close to the land as possible to prevent movement in the Z axis.
- Evidence of solder flow is discernible between swaged flange and land of the printed board or other substrate.

6.6.6 Terminals – Flared Flange Hardware (cont.)

Figure 6-66

Acceptable - Class 1,2

- Solder is around minimum of 270° of flange.
- Any split is filled with solder.
- Fillet of solder to at least 75% of flange height.

Acceptable - Class 3

- Solder is around minimum of 330° of flange.
- No radial or circumferential splits.
- Fillet of solder to at least 75% of flange height.

Figure 6-67

Defect - Class 1,2,3

- Improperly swaged, flange not seated on terminal area.
- Radial split not filled with solder.
- Solder does not reach up to 75% of flared flange height or 100% of flat set eyelet height.
- Solder is around less than 270° of flared flange or eyelet periphery.
- Circumferential split of flared flange or eyelet.

Defect - Class 3

- Solder is around less than 330° of flange.
- Any radial or circumferential split in flange.

6.7 Insulation

6.7.1 Insulation – In Solder

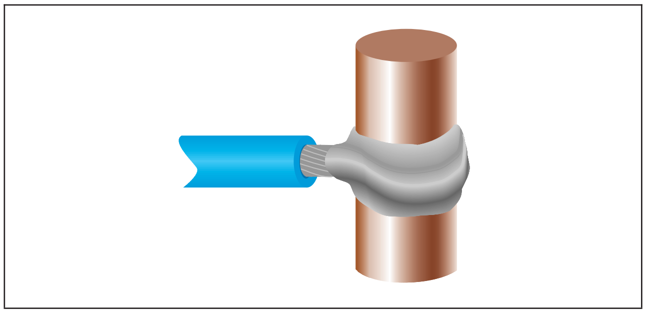

Figure 6-68

Acceptable - Class 1,2,3

• Limited solder wicking during soldering of wire is permissible as long as the solder does not extend to a portion of the wire which is required to remain flexible.

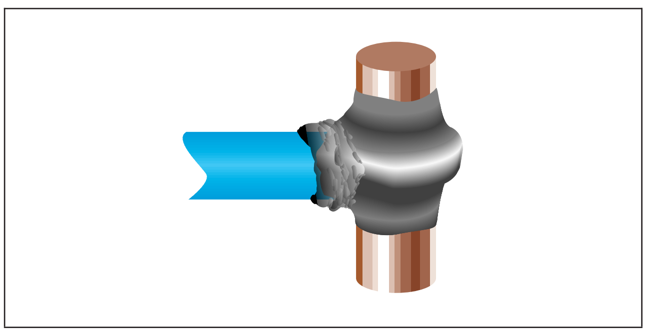

Figure 6-69

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

• The wire insulation is embedded in the solder.

6.7.2 Insulation – Damage

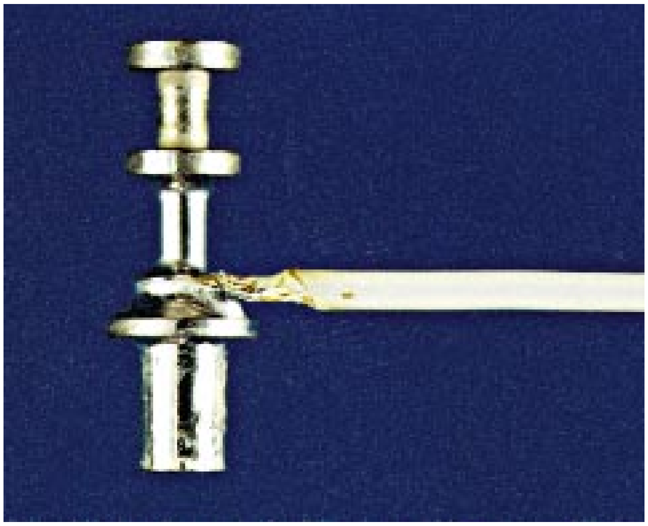

Figure 6-70

Acceptable - Class 1,2,3

- Slight melting of insulation discernible.

Figure 6-71

Defect - Class 1,2,3

- Insulation charred.
- Solder connection contaminated by burnt or melted insulation.

6.7.3 Insulation – Clearance

Figure 6-72

Target - Class 1,2,3

- Insulation clearance in tolerance.

Figure 6-73

Acceptable - Class 1,2,3

- Insulation clearance near zero.

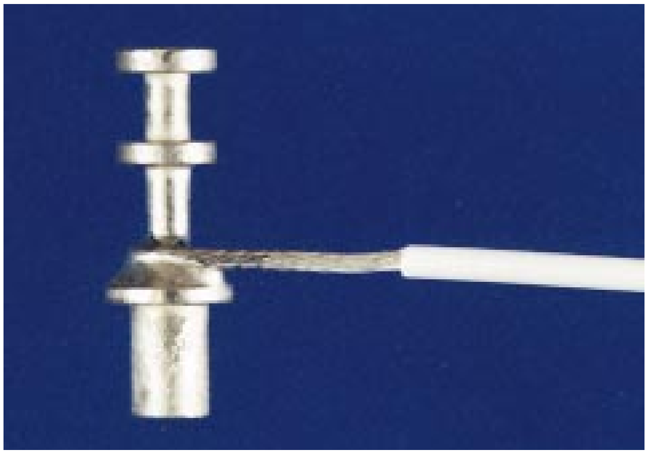

Figure 6-74

Acceptable - Class 1

- Exposed bare wire is acceptable providing there is no danger of shorting to adjacent circuitry when the wire is moved.

Process Indicator - Class 2,3

- The insulation clearance is greater than two wire diameters including insulation, or 1.5 mm [0.0591 in], whichever is greater.

Defect - Class 1,2,3

- Insulation clearance permits shorting to adjacent conductors.

6.8 High Voltage

This section provides the unique criteria for soldered connections that are subject to high voltages. Also see 4.2.3.3.

6.8.1 High Voltage - Terminals

6.8.1.1 High Voltage - Terminals - Wires/Leads

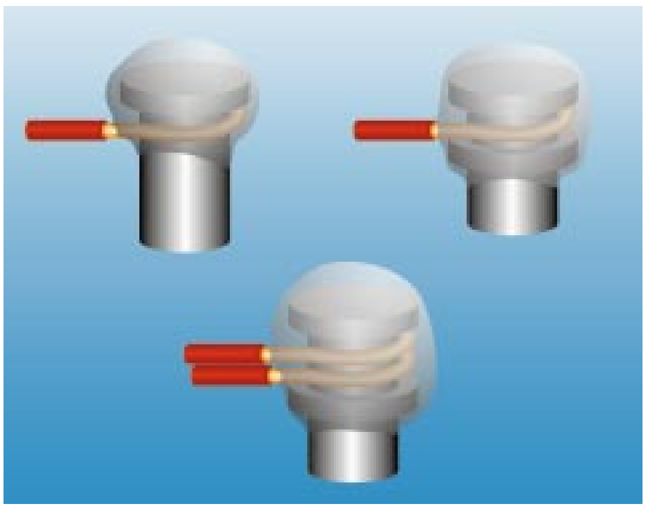

Figure 6-75

Target - Class 1,2,3

- Balled solder connection has a completely rounded, continuous and smooth profile.
- No evidence of sharp edges, solder points, icicles, inclusions (foreign material) or wire strands.
- Insulation clearance as close to the solder connection as possible without being embedded.

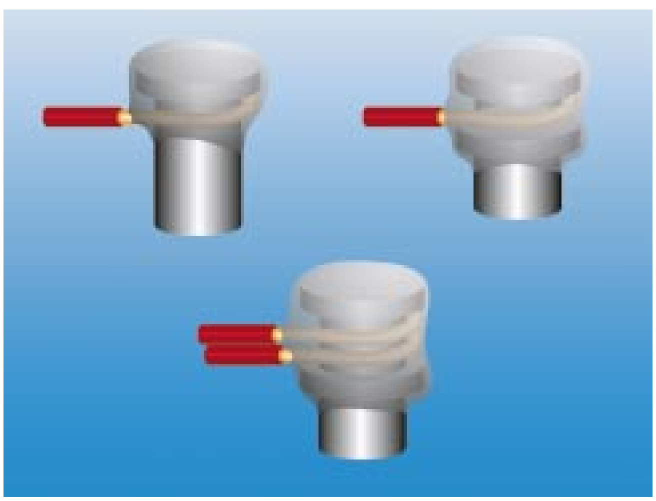

Figure 6-76

Acceptable - Class 1,2,3

- Solder connection has an egg-shaped, spherical or oval profile that follows the contour of terminal and wire wrap.
- No evidence of sharp edges, solder points, icicles, inclusions (foreign material) or wire strands.
- Sides may be a little rough with some layering or reflow lines.
- Balled solder connection does not exceed specified height requirements.
- Insulation clearance one wire diameter maximum.

6.8.1.1 High Voltage - Terminals - Wires/Leads (cont.)

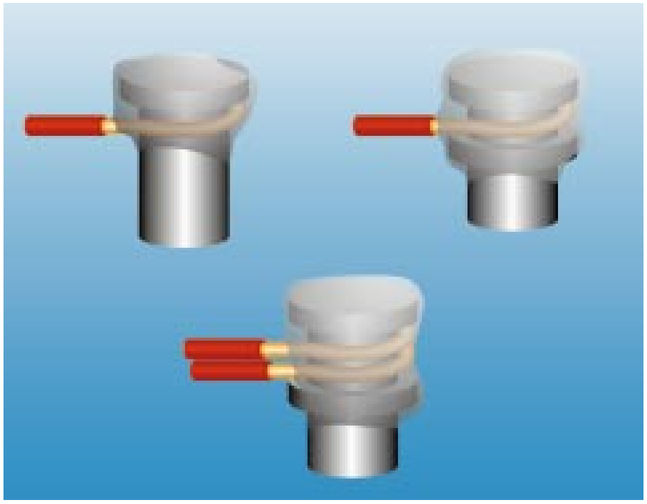

Figure 6-77

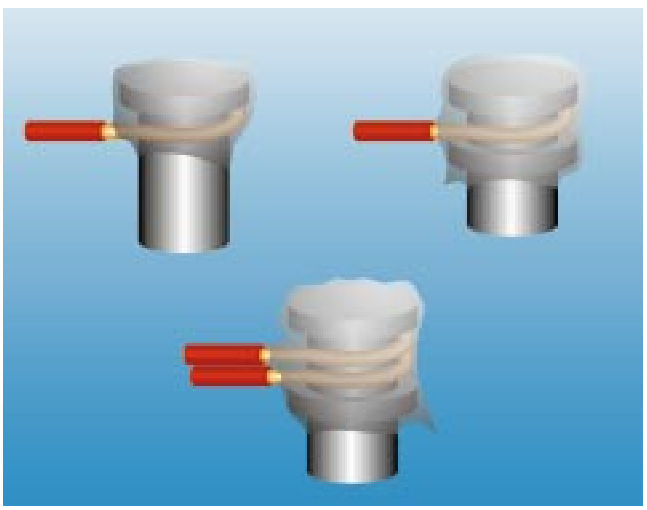

Figure 6-78

Defect - Class 1,2,3

- Solder follows contour of terminal and wire wrap but there is evidence of the sharp edge of the terminal protruding.
- Solder is round and continuous but there is evidence of solder peaks.
- Evidence of edges not smooth and round with nicks or crevices.
- Top of the solder connection is not smooth and continuous with layering or reflow lines.
- Evidence of wire strands not completely covered or discernible in the solder connection.
- Solder connection profile has a teardrop shape.

6.8.1.2 High Voltage - Terminals - Bottom Terminations

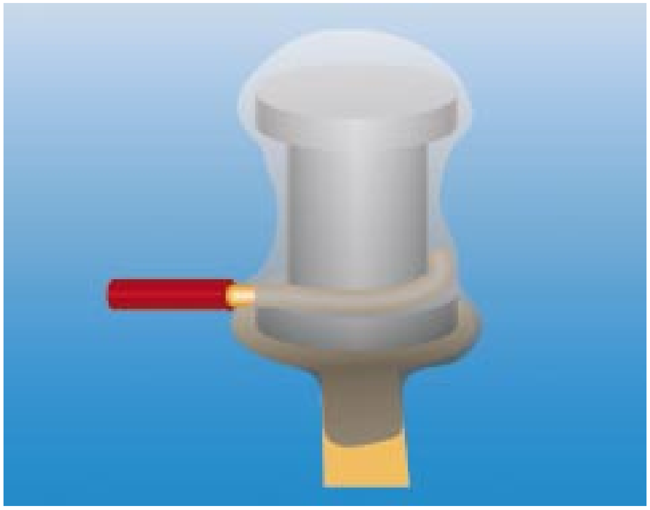

Figure 6-79

Acceptable - Class 1,2,3

- Wire/lead outline is discernible with a smooth flow of solder on wire/lead and terminal. Individual strands may be discernible.
- No evidence of sharp edges, solder points, icicles, or inclusions (foreign material).
- Balled solder connection does not exceed specified height requirements and meets all acceptable criteria for ball soldering.

6.8.1.3 High Voltage - Terminals - Unused

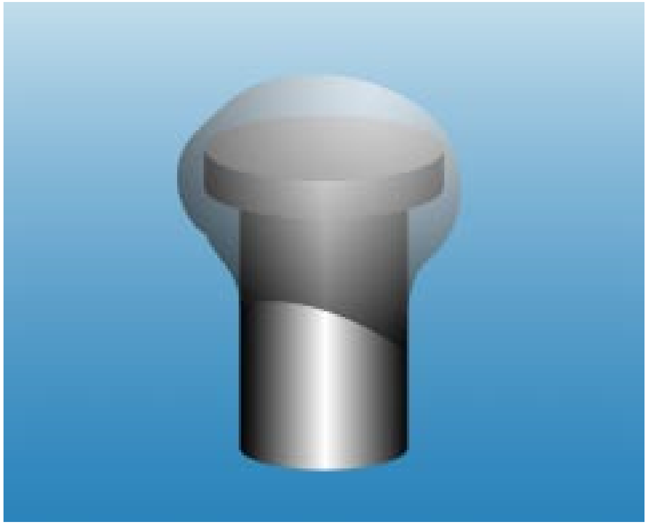

Figure 6-80

Acceptable - Class 1,2,3

- All sharp edges of the terminal are completely covered with a continuous smooth ball of solder.

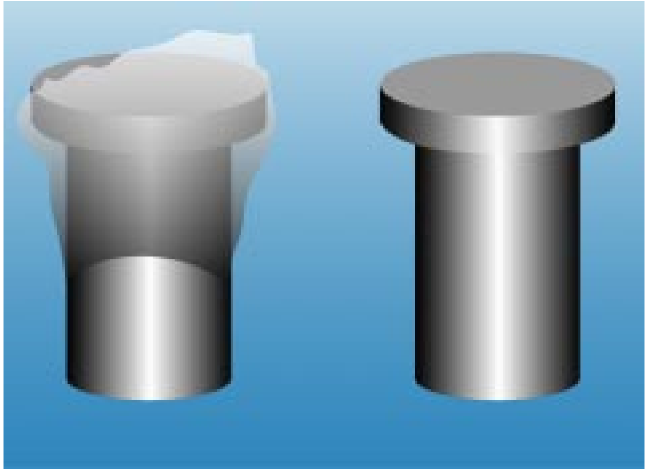

Figure 6-81

Defect - Class 1,2,3

- Solder is continuous but there is evidence of solder peaks, icicles or sharp turret edges protruding.
- Terminal lug is void of solder.

6.8.2 High Voltage - Solder Cups

6.8.2.1 High Voltage - Solder Cups - Wires/Leads

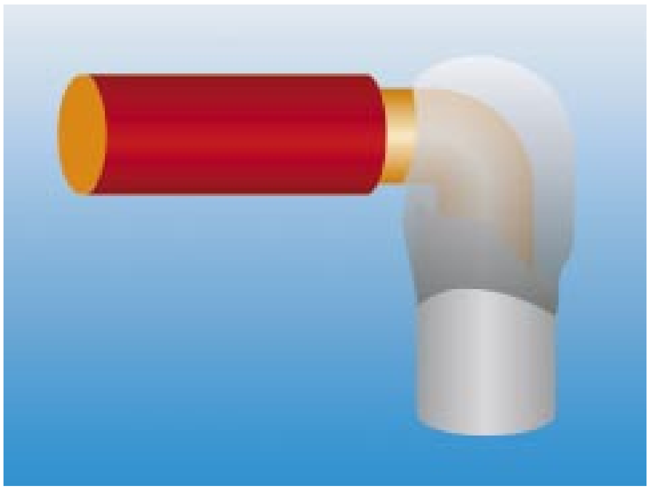

Figure 6-82

Acceptable - Class 1,2,3

- Solder connection has an egg-shaped, spherical or oval profile that follows the contour of wire wrap.
- No evidence of sharp edges, solder points, icicles, inclusions (foreign material) or wire strands.
- Insulation clearance one wire diameter maximum.
- Balled solder connection does not exceed specified height requirements and meets all acceptable criteria for ball soldering.

6.8.2.2 High Voltage - Solder Cups - Unused

Figure 6-83

Acceptable - Class 1,2,3

- Solder connection has an egg-shaped, spherical or oval profile.
- No evidence of sharp edges, solder points, icicles or inclusions (foreign material).
- Balled solder connection does not exceed specified height requirements and meets all acceptable criteria for ball soldering.

6.8.3 High Voltage - Insulation

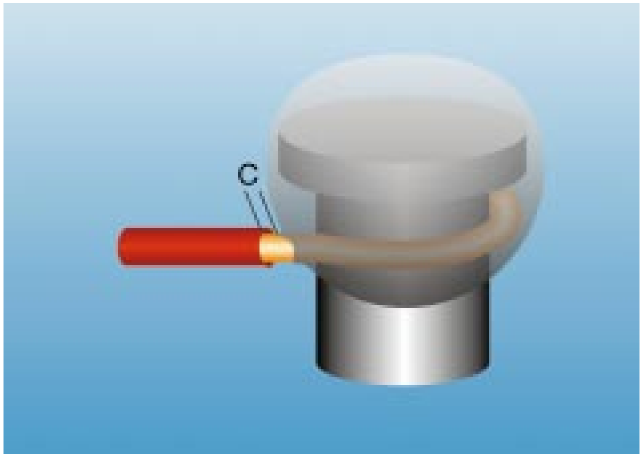

Figure 6-84

Target - Class 1,2,3

- Clearance (C) is minimal so that insulation is close to the solder connection without being embedded.
- Insulation is free of any damage (ragged, charred, melted edges or indentations).

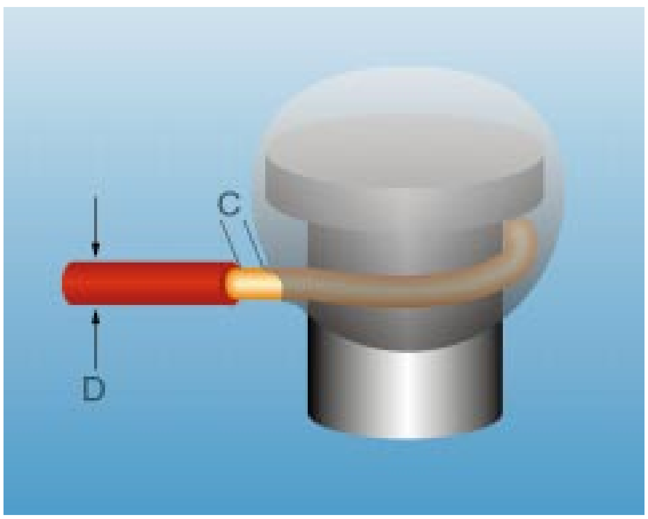

Figure 6-85

Acceptable - Class 1,2,3

- Insulation clearance (C) slightly less than one overall diameter (D) away from the solder connection.
- No evidence of insulation damage (ragged, charred, melted edges or indentations).

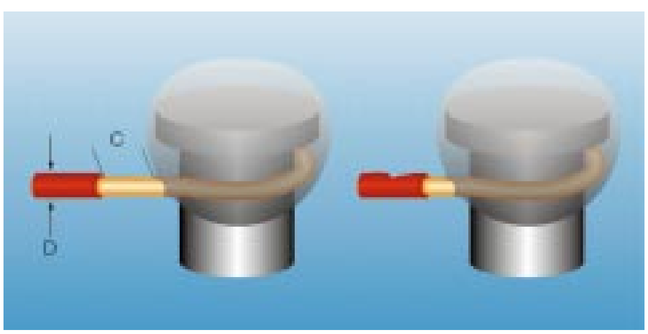

Figure 6-86

Defect - Class 1,2,3

- Insulation clearance (C) more than one overall diameter (D) away from the solder connection.
- Evidence of insulation damage (ragged, charred, melted edges or indentations).

6.8.4 High Voltage - Through-Hole Connections

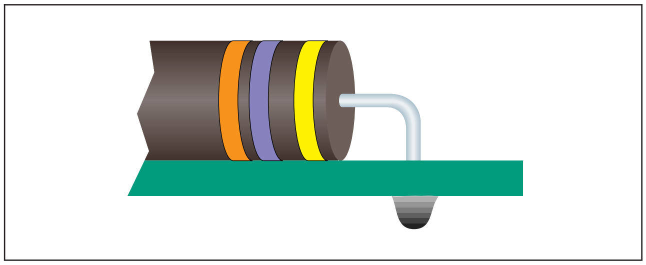

Figure 6-87

Acceptable - Class 1,2,3

- All sharp edges of the component lead are completely covered with a continuous smooth rounded layer of solder forming a solder ball.
- Straight-through leads facilitate ball soldering.
- Balled solder connection does not exceed specified height requirements.

6.8.5 High Voltage - Flared Flange Terminals

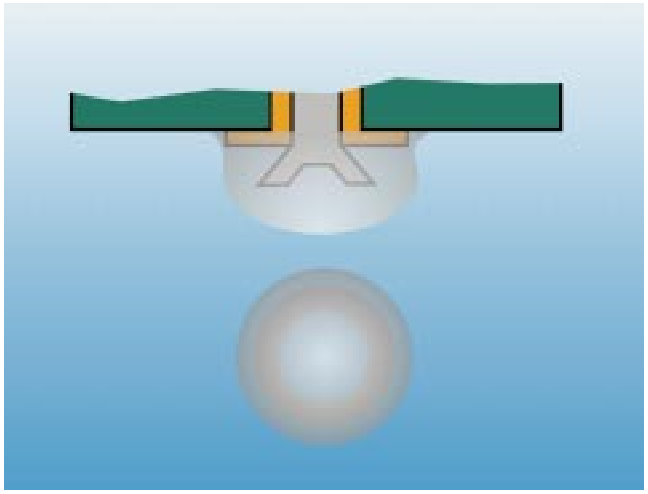

Figure 6-88

Target - Class 1,2,3

- All edges of the terminal are completely covered with a continuous smooth layer of solder forming a solder ball.
- Balled solder connection does not exceed specified height requirements.

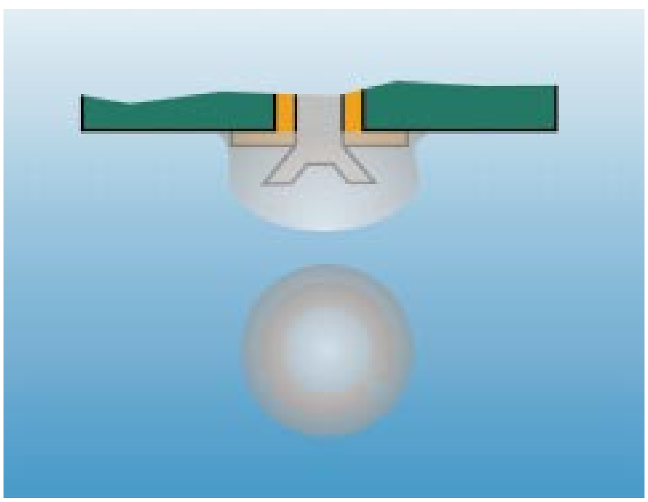

Figure 6-89

Acceptable - Class 1,2,3

- All sharp edges of the terminal's radial split are completely covered with a continuous smooth layer of solder forming a balled solder connection.
- Balled solder connection not exceed specified height requirements.

6.9 Connector Pins – Press Fit Pins

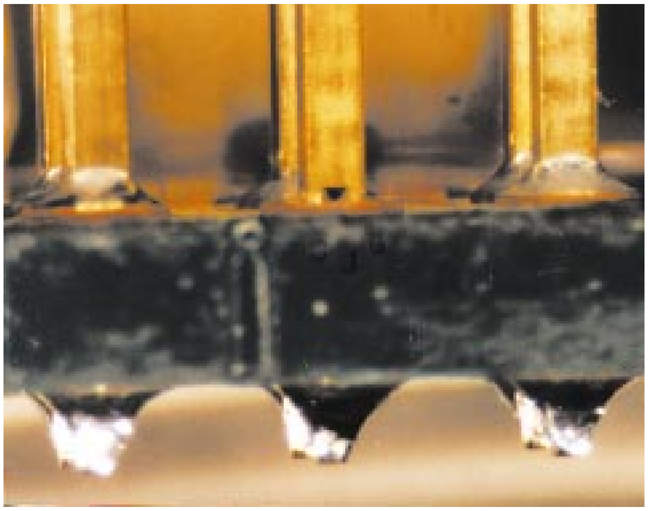

Figure 6-90

Target - Class 1,2,3

- A 360° solder fillet is evident on the secondary side of the assembly.

Note: Solder fillet or fill on primary side is not required.

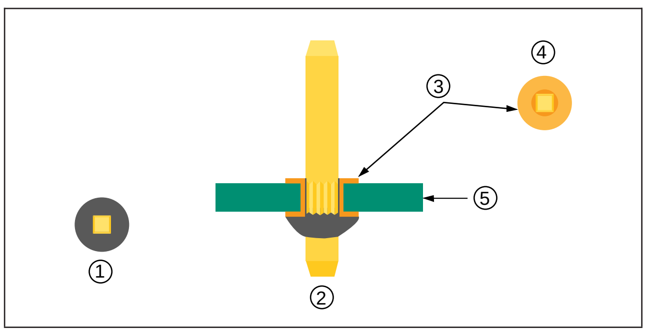

Figure 6-91
1. Bottom view
2. Side view
3. Land
4. Top view
5. PCB

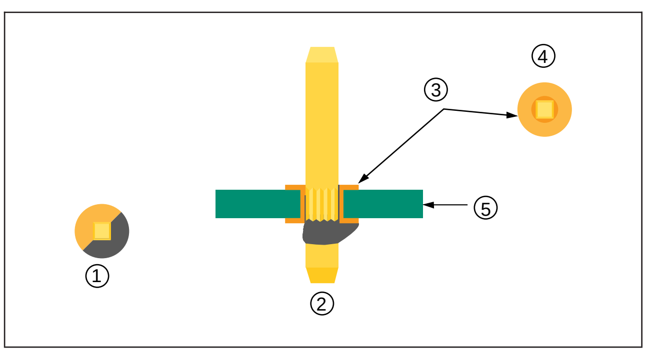

Figure 6-92
1. Bottom view
2. Side view
3. Land
4. Top view
5. PCB

Acceptable - Class 1,2

- Solder fillet or coverage (secondary side) is present on two adjacent sides of the pin.

6.9 Connector Pins – Press Fit Pins (cont.)

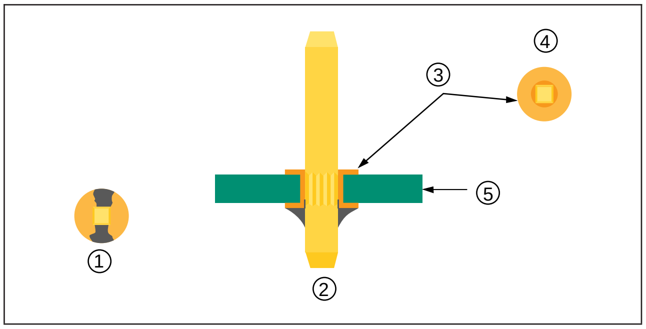

Figure 6-93
1. Bottom view
2. Side view
3. Land
4. Top view
5. PCB

Defect - Class 1,2

- Less than two adjacent sides with solder fillet.
- Less than two sides soldered.

Defect - Class 3

- Less than four sides of pin contain solder.

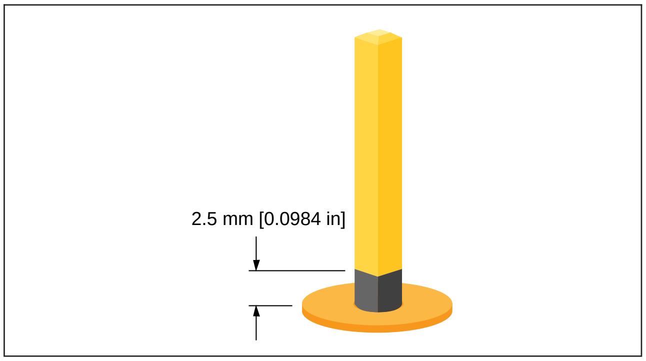

Figure 6-94

Acceptable - Class 1

- Solder wicking is permitted above 2.5 mm [0.0984 in] on sides of pins provided there is no solder build up which interferes with subsequent attachments to the pin.

Acceptable - Class 2,3

- Solder wicking on sides of pins is less than 2.5 mm [0.0984 in], provided the solder does not interfere with subsequent attachments to the pin.

Defect - Class 1,2,3

- Solder build up interferes with subsequent attachments to the pin.

Defect - Class 2,3

- Solder wicking exceeds 2.5 mm [0.0984 in].

6.10 Gold Fingers

See IPC-A-600, IPC-6011 and IPC-6012 for further criteria on gold fingers.

It is recommended to inspect with the unaided eye.

Critical contact area (any portion of the fingers that contacts the mating surface of the connector) is dependent upon the connector system scheme being used by the manufacturer. The documentation should identify those particular dimensions.

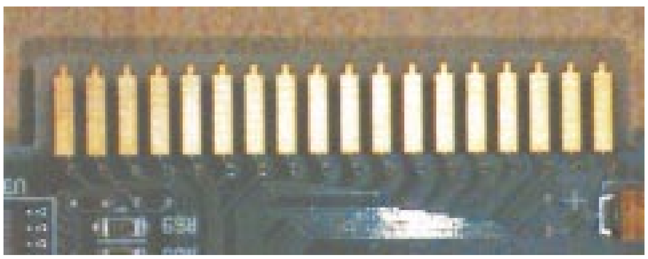

Figure 6-95

Target - Class 1,2,3

• No solder on gold fingers.

Acceptable - Class 1,2,3

• Solder is allowed in noncontact areas of fingers.

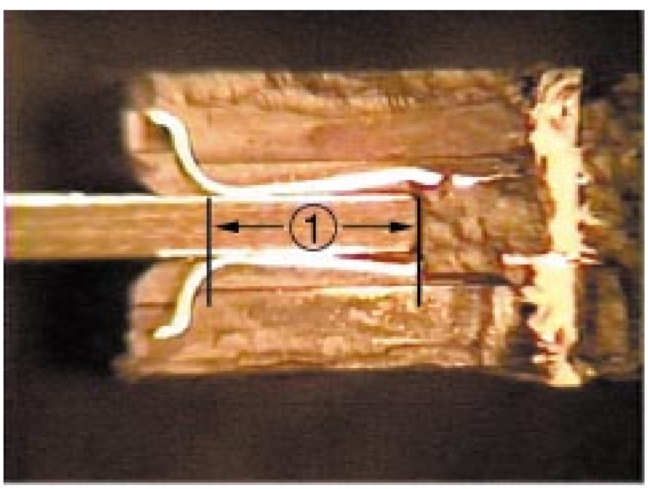

Figure 6-96

1. Critical contact area of edge fingers in contact with spring contact.

6.10 Gold Fingers (cont.)

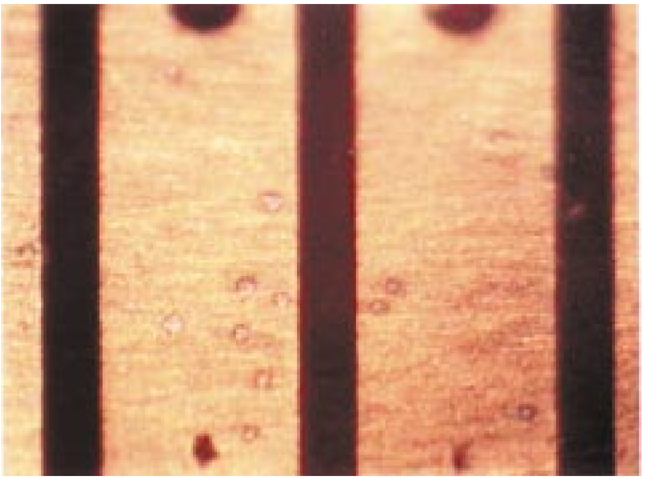

Figure 6-97

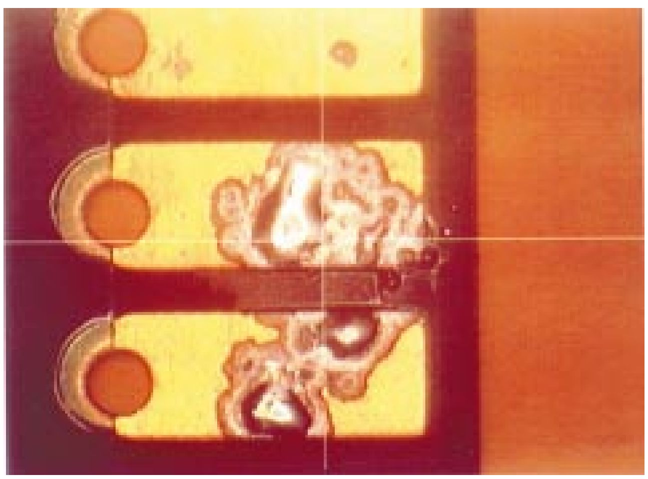

Figure 6-98

Defect - Class 1,2,3

- Solder, or any other metal other than gold, in the critical contact area of the fingers.

Cleanliness Acceptability Requirements

This section covers acceptability requirements for cleanliness of assemblies. The following are examples of the more common contaminants found on printed board assemblies. Others may appear, however, and all abnormal conditions should be evaluated. The conditions represented in this section apply to both primary and secondary sides of the assemblies. See IPC-CH-65 for additional cleaning information.

Contaminant is not only to be judged on cosmetic or functional attributes, but as a warning that something in the cleaning system is not working properly.

Testing a contaminant for functional effects is to be performed under conditions of the expected working environment for the equipment.

Every production facility should have a standard based on how much of each type of contaminant can be tolerated. The more cleaning that has to be done, the more expensive the assembly. Testing with ionic extract devices based on J-STD-001, insulation resistance tests under environmental conditions and other electrical parameter tests as described in IPC-TM-650 are recommended for setting a facility standard.

This section addresses the following subjects:

7.1 Flux Residues

The flux classification (i.e., no-clean, clean, etc.) will be identified and considered prior to application of the following acceptance criteria. (See ANSI/J-STD-004.)

Figure 7-1

Target - Class 1,2,3

- Clean, no discernible residue.

Acceptable - Class 1,2,3

- No discernible residue from cleanable fluxes is allowed.
- Flux residues from no-clean processes may be allowed.

Figure 7-2

Defect - Class 1,2,3

- Discernible residue from cleanable fluxes, or any activated flux residues on electrical contact surfaces.

Note 1. Class 1 may be acceptable after qualification testing. Check also for flux entrapment in and under components.

Note 2. Flux residue activity is defined in IPC/EIA J-STD-001 and ANSI/J-STD-004.

Note 3. Processes designated ''no-clean'' need to comply with end-product cleanliness requirements.

7.2 Particulate Matter

Figure 7-3

Target - Class 1,2,3

- Clean.

Figure 7-4

Defect - Class 1,2,3

- Dirt and particulate matter on assembly, e.g., dirt, lint, dross, metallic particles, etc.

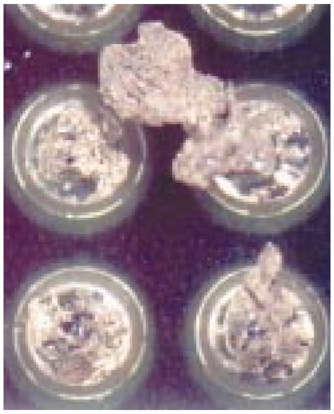

Figure 7-5

Figure 7-6

7.3 Chlorides, Carbonates and White Residues

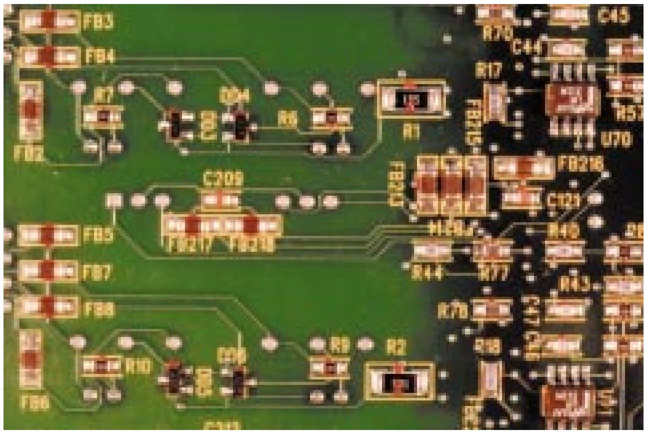

Figure 7-7

Target - Class 1,2,3

• No discernible residue.

7.3 Chlorides, Carbonates and White Residues (cont.)

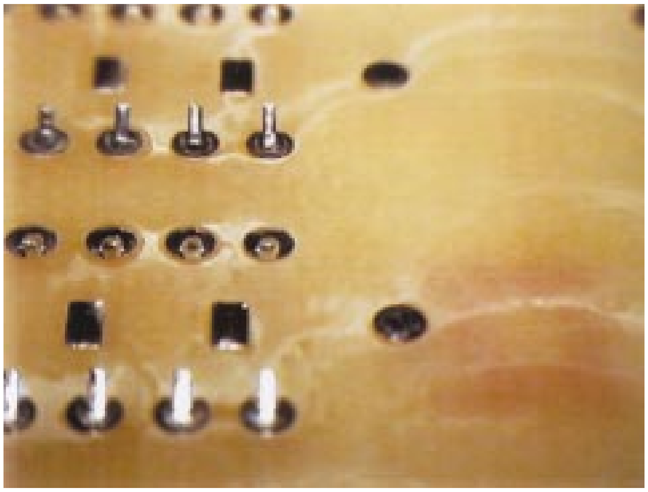

Figure 7-8

Figure 7-9

Figure 7-10

Defect - Class 1,2,3

- White residue on PWB surface.
- White residues on or around the soldered termination.
- Metallic areas exhibit crystalline white deposit.

Note: White residues resulting from no-clean or other processes are acceptable provided the residues from chemistries used have been qualified and documented as benign. See 7.4.

7.4 Flux Residues – No-Clean Process – Appearance

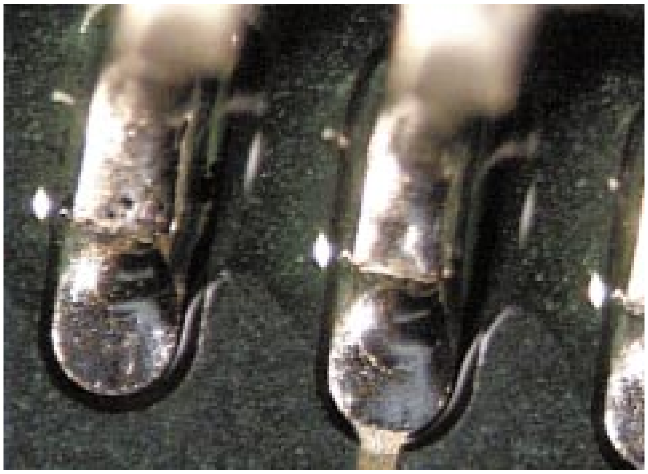

Figure 7-11

Acceptable - Class 1,2,3

- Flux residue on, around, or bridging between noncommon lands, component leads and conductors.
- Flux residue does not inhibit visual inspection.
- Flux residue does not inhibit access to test points of the assembly.

Defect - Class 2,3

- Flux residue inhibits visual inspection.

Note 1. There is no defect for discoloration for OSP coated assemblies that come in contact with flux residues from no-clean process.

Note 2. Residue appearance may vary depending upon flux characteristics and solder methods.

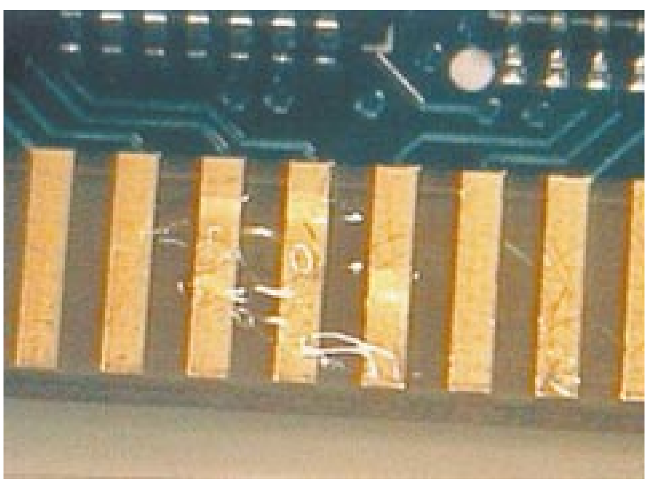

Figure 7-12

Acceptable - Class 1
Process Indicator - Class 2
Defect - Class 3

- Finger prints in no-clean residue.

Defect - Class 1,2,3

- Wet, tacky, or excessive flux residues that may spread onto other surfaces.
- No-clean flux residue on any electrical mating surface that inhibits electrical connection.

7.5 Surface Appearance

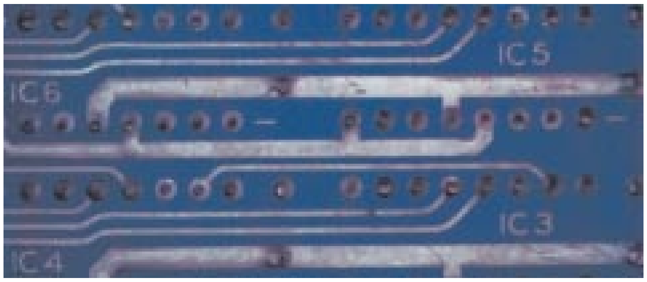

Figure 7-13

Acceptable - Class 1,2,3

- Slight dulling of clean metallic surfaces.

7.5 Surface Appearance (cont.)

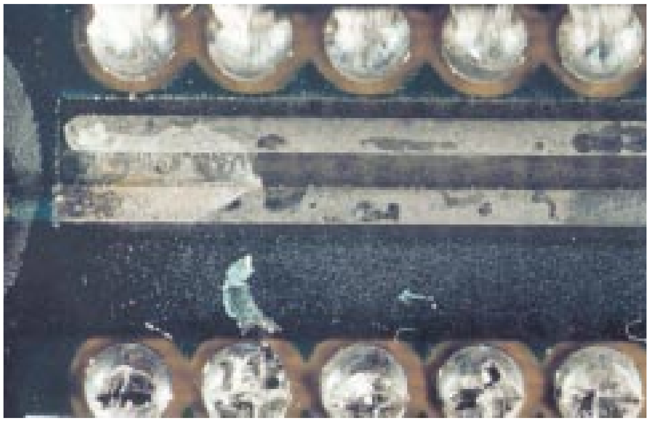
Figure 7-14

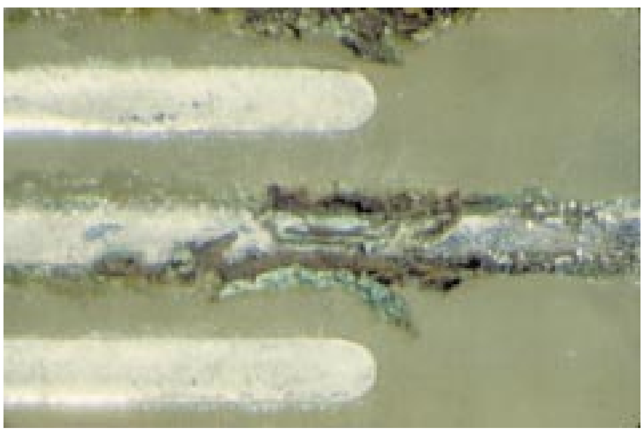
Figure 7-15

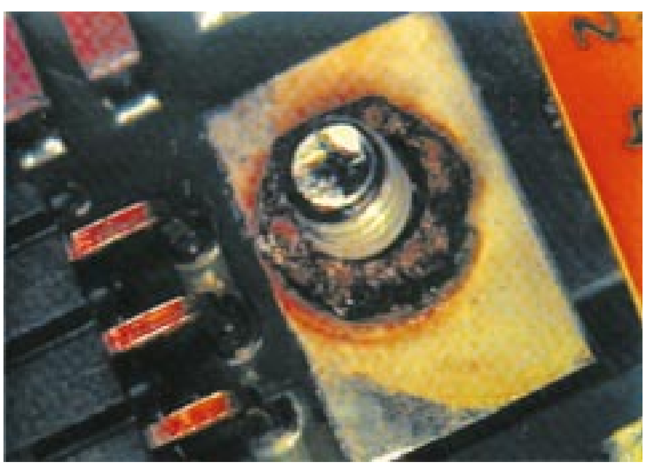
Figure 7-16

Defect - Class 1,2,3

- Colored residues or rusty appearance on metallic surfaces or hardware.
- Evidence of corrosion.

Marking Acceptability Requirements

This section covers acceptability criteria for marking of printed boards and other electronic assemblies.

Marking provides both product identification and traceability. It aids in assembly, in-process control, and field servicing. The methods and materials used in marking must serve the intended purposes and must be readable, durable, and compatible with the manufacturing processes and should remain legible through the life of the product.

Examples of the markings addressed by this section include the following:

a. Electronic Assemblies:

- company logo
- board fabrication part numbers and revision level
- assembly part number, group number, and revision level
- component legends including reference designators and polarity indicators (only applies prior to assembly processing/cleaning)
- certain inspection and test traceability indicators
- U.S. and other relevant regulatory agencies/certifications
- unique individual serial number
- date code

b. Modules and/or Higher Level Assemblies:

- company logo
- product identification numbers
- installation and user information
- relevant regulatory agencies' certification labels

The fabrication and assembly drawings are the controlling documents for the locations and types of markings. Marking criteria specified in the drawings will take precedence over this criterion.

In general, additive markings over metal surfaces are not recommended. Markings which serve as aids to assembly and inspection need not be visible after the components are mounted.

Assembly marking (part numbers, serial numbers) shall remain legible (capable of being read and understood as defined by the requirements of this standard) after all tests, cleaning and other processes to which the item is subjected. Component markings, reference designators and polarity indicators should be legible and components should be mounted in such a manner that markings are visible. Markings are not deliberately altered, obliterated, or removed by the manufacturer unless required by the assembly drawing(s)/documentation. Additional markings such as labels added during the manufacturing process should not obscure the original supplier's markings. Permanent labels need to comply with the adhesion requirements of 8.5.3. Components and fabricated parts need not be mechanically installed so that the reference designations are visible when installed.

Acceptance of the marking is based on using the unaided eye. If magnification is required, do not use greater than 4X.

Marking inks need to be nonconductive.

This section addresses the following topics:

8.1 Etched Marking (Including Hand Printing)

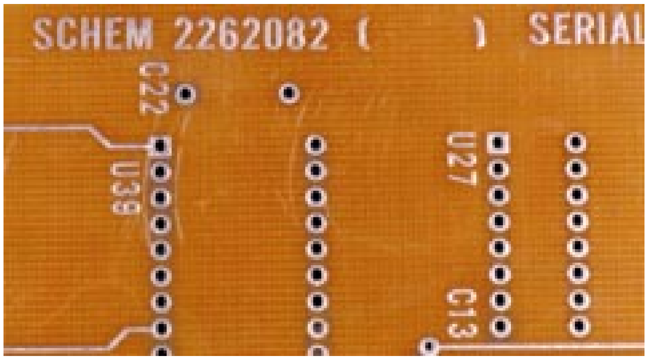

Figure 8-1

Target - Class 1,2,3

- Each number or letter is complete, i.e., none of the lines forming a character are missing or broken.
- Polarity and orientation markings are present and legible.
- Lines forming the character are sharply defined and uniform in width.
- Minimum spacing requirements between active conductors have also been maintained between etched symbolization and active conductors.

Figure 8-2

Acceptable - Class 1,2,3

- Edges of the lines forming a character may be slightly irregular. Open areas within characters may be filled providing the characters are legible and cannot be confused with another letter or number.
- Width of the lines forming a character may be reduced by up to 50% providing they remain legible.
- Lines of a number or letter may be broken provided the breaks do not make the marking illegible.

Figure 8-3

Acceptable - Class 1
Process Indicator - Class 2,3

- Legends are irregularly formed but the general intent of the legend or marking is discernible.

Defect - Class 1,2,3

- Missing or illegible characters in the markings.
- Marking violates the minimum electrical clearance limits.
- Solder bridging within or between characters or characters/conductors preventing character identification.
- Lines forming a character are missing or broken to the extent that the character is not legible or is likely to be confused with another character.

8.2 Screened Marking

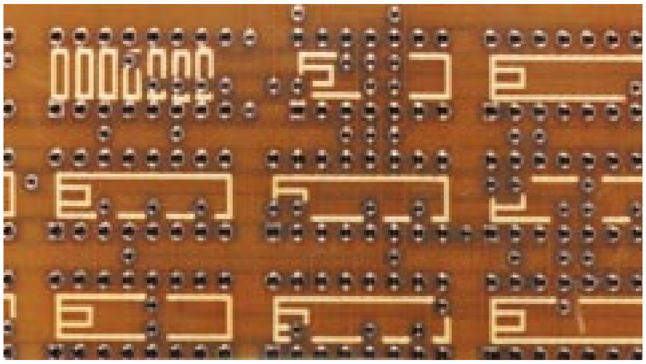

Figure 8-4

Target - Class 1,2,3

- Each number or letter is complete i.e., none of the lines forming a character are missing or broken.
- Polarity and orientation markings are present and legible. Lines forming the character are sharply defined and uniform in width.
- Ink forming the markings is uniform, i.e., there are no thin spots or excessive build-ups.
- The open areas within characters are not filled (applies to numbers 0, 6, 8, 9, and letters A, B, D, O, P, Q, R).
- There are no double images.
- Ink is confined to the lines of the character, i.e., there are no smeared characters and the build-up of material outside the characters is held to a minimum.
- Ink markings may touch or cross over conductors but are no closer than tangent to a land.

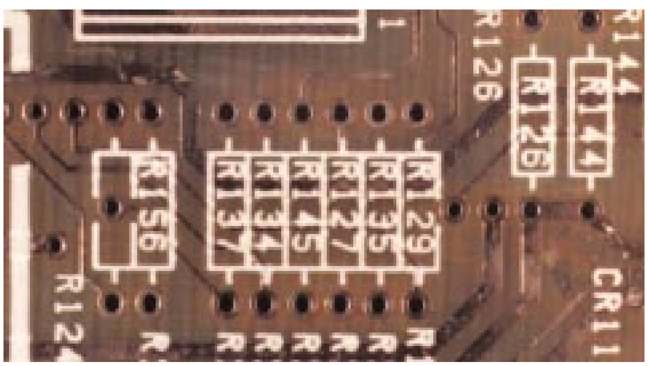

Figure 8-5

Acceptable - Class 1,2,3

- Ink may be built up outside the line of a character providing the character is legible.
- Marking ink on the land does not interfere with soldering requirements.

Acceptable - Class 1
Process Indicator - Class 2,3

- Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the breaks do not make the markings illegible.

Process Indicator - Class 2,3

- The open areas within characters may be filled providing the characters are legible, i.e., cannot be confused with another letter or number.

Defect - Class 1,2,3

- Marking ink is present on the land interfering with the solder requirements of Table 6-2 or with the surface mount soldering requirements of Section 12.

8.2 Screened Marking (cont.)

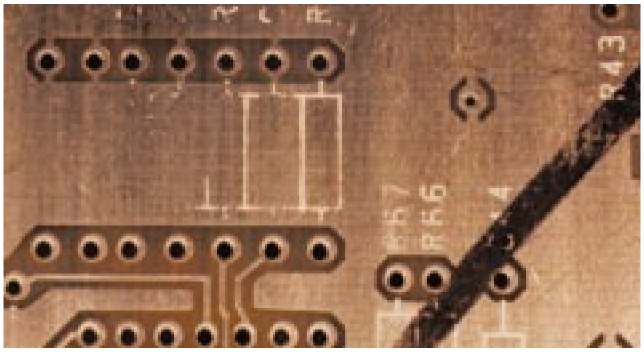

Figure 8-6

Acceptable - Class 1
Process Indicator - Class 2,3

- Marking that is smeared or blurred but is still legible.
- Double images that are legible.

Defect - Class 1,2,3

- Missing or illegible markings or reference designators for component location, or component outlines.
- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.

8.3 Stamped Marking

Figure 8-7

Target - Class 1,2,3

- Each number or letter is complete, i.e., none of the lines forming a character are missing or broken.
- Polarity and orientation markings are present and legible.
- Lines forming the character are sharply defined and uniform in width.
- Ink forming the markings is uniform, i.e., there are no thin spots or excessive build-ups.
- The open areas within characters are not filled (applies to numbers 0, 6, 8, 9 and letters A, B, D, O, P, Q, R).
- There are no double images.
- Ink is confined to the lines of the character, i.e., there are no smeared characters and the build-up of material outside the characters is held to a minimum.
- Ink markings may touch or cross over conductors but are no closer than tangent to a solderable land.

8.3 Stamped Marking (cont.)

Figure 8-8

Acceptable - Class 1,2,3

- Ink may be built up outside the line of a character providing the character is legible.
- Marking ink is present on the land (see soldering requirements of Table 6-2 or the surface mount soldering requirements of Section 12).

Acceptable - Class 1
Process Indicator - Class 2,3

- Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the breaks do not make the markings illegible.
- The open areas within characters may be filled providing the characters are legible, i.e., cannot be confused with another letter or number.

Defect - Class 1,2,3

- Marking ink is present on the land interfering with the solder requirements of Table 6-2 or with the surface mount soldering requirements of Section 12.

Figure 8-9

Acceptable - Class 1
Process Indicator - Class 2,3

- Marking that has been smeared or blurred but is still legible.
- Double stamped markings are acceptable provided the general intent can be determined.
- Missing or smeared marking does not exceed 10% of the character and the character is still legible.

Defect - Class 1,2,3

- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.

8.4 Laser Marking

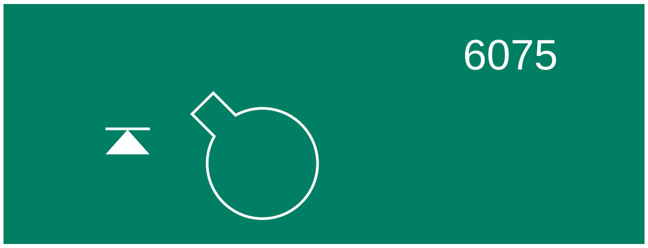

Figure 8-10

Target - Class 1,2,3

- Each number or letter is complete, and legible, i.e., none of the lines forming a character are missing or broken.
- Polarity and orientation markings are present and legible.
- Lines forming the character are sharply defined and uniform in width.
- Marking forming the characters is uniform, i.e., there are no thick or thin spots.
- The open areas within characters are not filled (applies to numbers 0, 6, 8, 9 and A, B, D, O, P, Q, R).
- Marking is confined to the lines of the character, i.e., there are no smeared characters and markings do not touch or cross over solderable surfaces.
- The depth of the marking does not adversely affect the function of the part.
- There is no exposed copper when marking on the ground plane of printed wiring boards.
- There is no delamination when marking on the printed wiring board dielectric.

Figure 8-11

Acceptable - Class 1,2,3

- Marking may be built up outside the line of a character providing the character is legible.

8.4 Laser Marking (cont.)

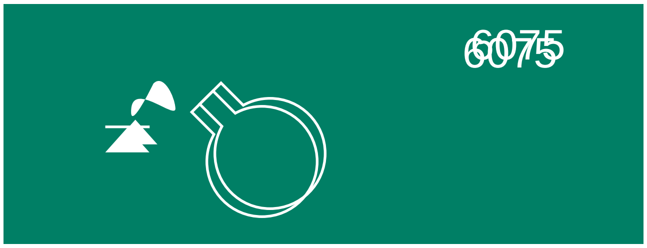

Figure 8-12

Acceptable - Class 1
Process Indicator - Class 2,3

- Multiple image is still legible.
- Missing or smeared marking is not more than 10% of the character.
- Lines of a number or letter may be broken (or thin over a portion of the character).
- Marking to hole distance is approximately 0.25 mm [0.00984 in] or more.

Defect - Class 1,2,3

- Missing or illegible characters in the markings.
- Open areas of characters are filled and are not legible, or are likely to be confused with another number or letter.
- Lines forming a character are missing, broken or smeared to the extent that the character is not legible or is likely to be confused with another character.
- The depth of the marking adversely affects the function of the part.
- Marking exposes copper on the ground plane of printed wiring boards.
- Delamination on the printed wiring board dielectric from marking.
- Markings touch or cross over solderable surfaces.

8.5 Labels

Permanent labels are commonly used to attach bar code data, but may include text. Readability, adhesion and damage criteria applies to all permanent labels.

8.5.1 Labels – Bar Coding

Bar coding has gained wide acceptance as a method of product identification, process control and traceability because of ease and accuracy of data collection and processing. Bar code labels are available which occupy small areas (some can be attached to the thickness edge of the PWB) and can withstand the normal wave soldering and cleaning operations. Bar coding can also be laser scribed directly on to the base material. Acceptability requirements are the same as other types of markings except the legibility issue where machine readability replaces human readability.

8.5.2 Labels – Readability

Figure 8-13

Target - Class 1,2,3

- No spots or voids on printed surfaces.

Acceptable - Class 1,2,3

- Spots or voids on printed surfaces of bar codes are permissible provided that either:
  - Bar code can be read successfully with three (3) or fewer attempts using a wand type scanner.
  - The bar code can be read successfully with two (2) or fewer attempts using a laser scanner.

Defect - Class 2,3

- Bar code cannot be successfully read within three (3) attempts using a wand type scanner.
- Bar code cannot be read successfully within two (2) attempts using a laser scanner.

8.5.3 Labels – Adhesion and Damage

Figure 8-14

Target - Class 1,2,3

- Adhesion is complete, shows no sign of damage or peeling.
- Bar code/text meet readability criteria.

Figure 8-15

Acceptable - Class 1
Process Indicator - Class 2,3

- Label shows sign of edge peeling on 10% or less of the label area and still meets acceptable readability criteria.

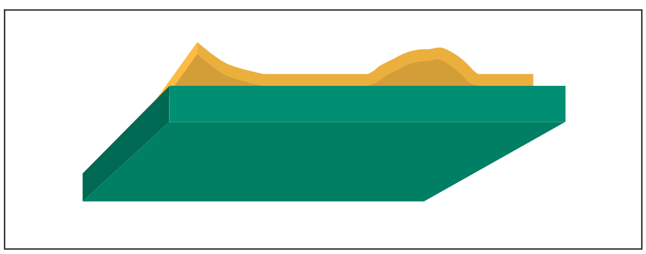

Figure 8-16

Defect - Class 2,3

- More than 10% of the label area is peeling.

Defect - Class 1,2,3

- Missing labels.
- Label fails acceptable readability criteria.

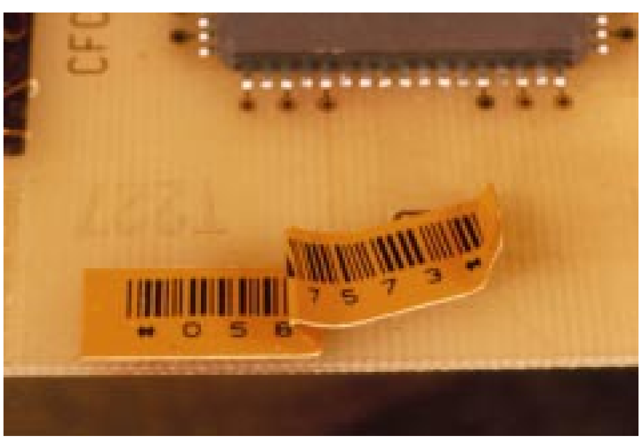

Figure 8-17

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Coatings Acceptability Requirements

This section covers the acceptability requirements for conformal coatings and solder resist coatings on electronic assemblies.

Each electronic assembly has specific functional requirements that will control the demands placed on the coating. Some requirements will be purely cosmetic (nonfunctional), while others will affect functional performance of the board.

The choice of coating material or process must be based on what that material will be required to do. For example, will the coating function strictly as a solder resist or provide lifetime environmental protection to the board?

Even a purely cosmetic defect in coatings usually indicates an improper material choice or process problem which needs to be corrected.

Additional information on solder resist is available in IPC-SM-840, and information on conformal coating is available in IPC-CC-830.

This section addresses the following subjects:

9.1 Conformal Coating

9.1.1 Conformal Coating – General

The coatings should be transparent and uniformly cover the board and components.

The coatings should be properly cured and not exhibit tackiness.

The coatings should be uniform in color and consistency.

Uniform coating distribution depends partly on the method of application and may affect visual appearance and corner coverage. Assemblies coated by dipping may have a drip line or localized build-up of the edge of the board. This build-up may contain a small amount of bubbles. but it will not affect the functionality or reliability of the coating.

9.1.2 Conformal Coating – Coverage

Areas that are specified to be coated are coated. Areas that are specified not to be coated are to be free of coating. The assembly may be examined with the unaided eye. Magnification from 1.75X to 4X may be used for referee purposes. Materials that contain a fluorescent pigment may be examined with blacklight to verify coverage. White light may be used as an aid for examining coverage.

Conformal coating is to be of the type specified on the assembly drawing and:

a. Be completely cured and homogeneous.
b. Cover only those areas specified on the assembly drawing.
c. Be free of blisters or breaks that affect the assembly operations or sealing properties of the conformal coating.
d. Be free of voids, bubbles, or foreign material which expose component conductors, printed wiring conductors (including ground planes) or other conductors, and/or violate minimum electrical clearance.
e. Contain no mealing, peeling, or wrinkles (nonadherent areas).

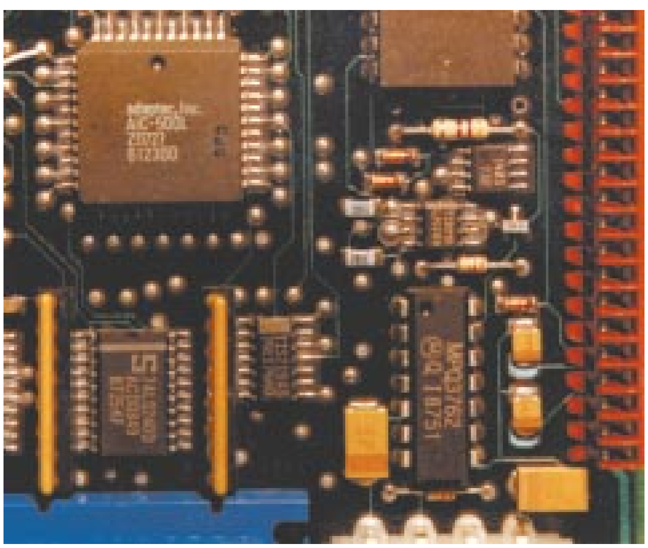

Figure 9-1

Target - Class 1,2,3

- Conformal coating shows no loss of adhesion from the board surface that bridges lands, components, or conductive surfaces.
- The coating does not exhibit dewetting and is free of voids, bubbles, ripples, fisheyes, or orange peel.
- The coating does not contain foreign material.

9.1.2 Conformal Coating – Coverage (cont.)

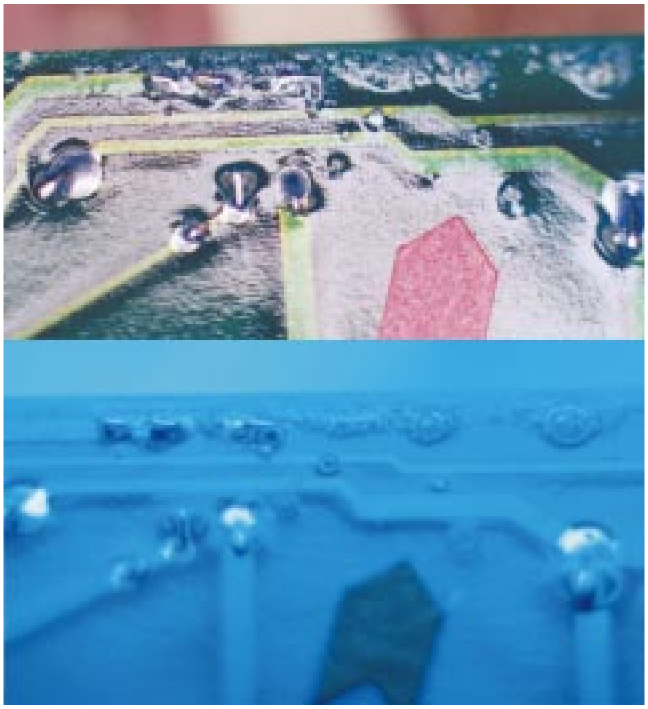

Figure 9-2

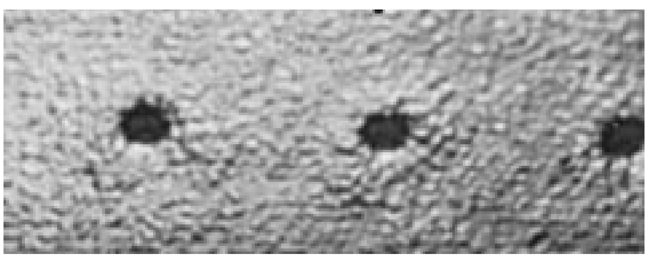

Figure 9-3

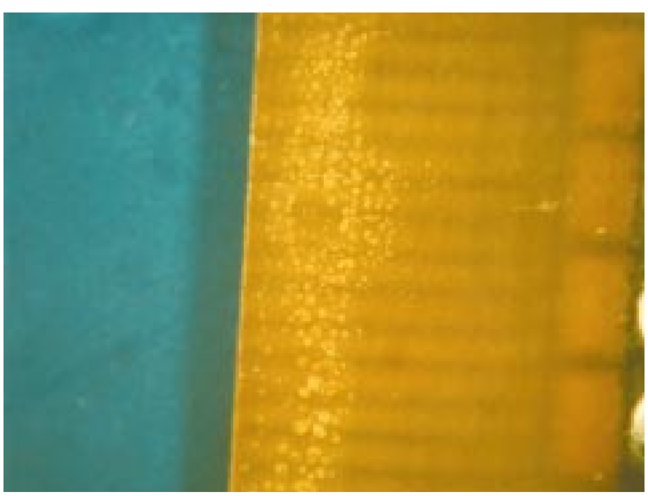

Figure 9-4

Acceptable - Class 1,2,3

- Conformal coating may show a loss of adhesion adjacent to masking.
- Voids do not expose circuitry, bridge lands or adjacent conductor surfaces.
- The coating may exhibit dewetting, ripples, fisheyes, or orange peel. (Figure 9-3)
- Foreign material does not violate minimum electrical clearance between components, lands, or conductive surface.

9.1.2 Conformal Coating – Coverage (cont.)

Figure 9-5

Defect - Class 1,2,3

- Any foreign material that violates minimum electrical clearance between components, lands or conductive surfaces.
- Any voids, bubbles, adhesion loss (mealing), dewetting, ripples, fisheyes, orange peel, or foreign material that expose circuitry, bridge lands or adjacent conductive surfaces.
- Coating has not been applied to required areas.
- Coating on areas required to be free of coating.

9.1.3 Conformal Coating - Thickness

Table 9-1 Coating Thickness

Type AR	Acrylic Resin	0.03-0.13 mm [0.00118-0.00512 in]
Type ER	Epoxy Resin	0.03-0.13 mm [0.00118-0.00512 in]
Type UR	Urethane Resin	0.03-0.13 mm [0.00118-0.00512 in]
Type SR	Silicone Resin	0.05-0.21 mm [0.00197-0.00827 in]
Type XY	Paraxylene Resin	0.01-0.05 mm [0.00039-0.00197 in]

Table 9-1 provides coating thickness requirements. The thickness is to be measured on a flat, unencumbered, cured surface of the printed wiring assembly or a coupon that has been processed with the assembly. Coupons may be of the same type of material as the printed board or may be of a non-porous material such as metal or glass. As an alternative, a wet film thickness measurement may be used to establish the coating thickness provided there is documentation that correlates the wet and dry film thickness. Conformal coating on tip of the lead is not required.

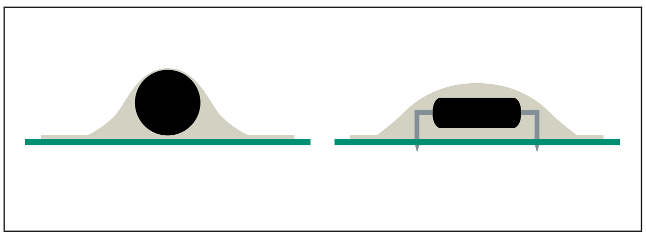

Figure 9-6

Acceptable - Class 1,2,3

- Coating meets the thickness requirements of Table 9-1.

Defect - Class 1,2,3

- Coating does not meet thickness requirements of Table 9-1.

9.2 Solder Resist Coating

Solder Resist (Mask) A heat-resisting coating material applied to selected areas to prevent the deposition of solder upon those areas during subsequent soldering. Solder resist material may be applied as a liquid or a dry film. Both types meet the requirements of this guideline.

Note: In addition, solder resist is useful in preventing PWB surface damage during assembly operations. Although not rated for dielectric strength, and therefore not satisfying the definition of an ‘‘insulator or insulative material,’’ some solder resist formulations provide limited insulation and are commonly used as surface insulation where high voltages are not a consideration.

Tape Test - The tape test referenced in this section is IPC-TM-650, Test Method 2.4.28.1. All loose and nonadhering material needs to be removed.

See IPC-A-600.

9.2.1 Solder Resist Coating – Wrinkling/Cracking

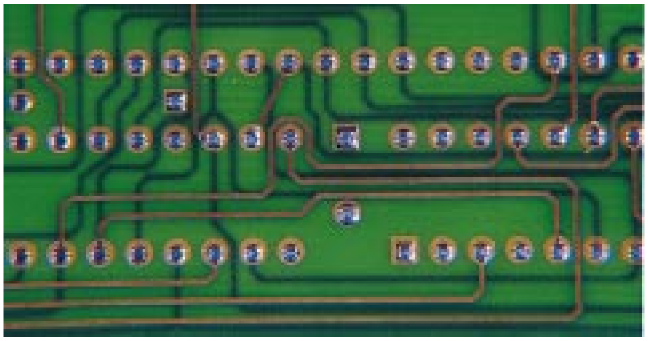

Figure 9-7

Target - Class 1,2,3

- There is no evidence of cracking of the solder resist after the soldering and cleaning operations.

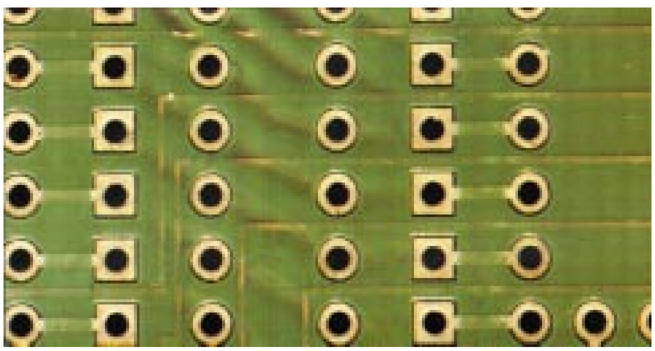

Figure 9-8

Acceptable - Class 1,2,3

- Minor wrinkling is located in an area that does not bridge between conductive patterns and meets the adhesion tape pull test, IPC-TM-650, 2.4.28.1

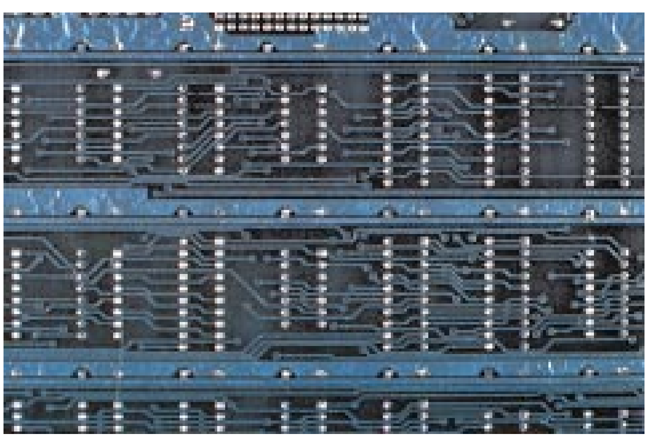

Figure 9-9

Acceptable - Class 1,2,3

- Wrinkling of the solder resist film over area of reflowed solder is acceptable providing there is no evidence of breaking, lifting or degradation of the film. Adhesion of wrinkled areas can be verified using a tape pull test.

9.2.1 Solder Resist Coating – Wrinkling/Cracking (cont.)

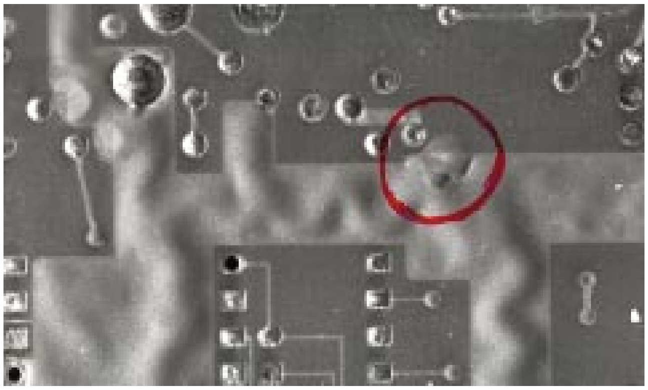

Figure 9-10

Acceptable - Class 1,2
Defect - Class 3

- Cracking of solder resist.

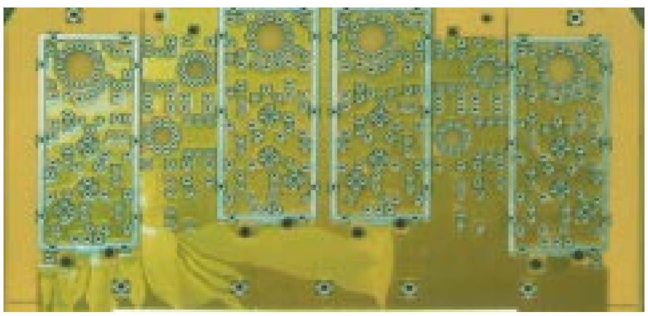

Figure 9-11

Defect - Class 1,2,3

- Loose particles cannot be completely removed and will affect the operation of the assembly.

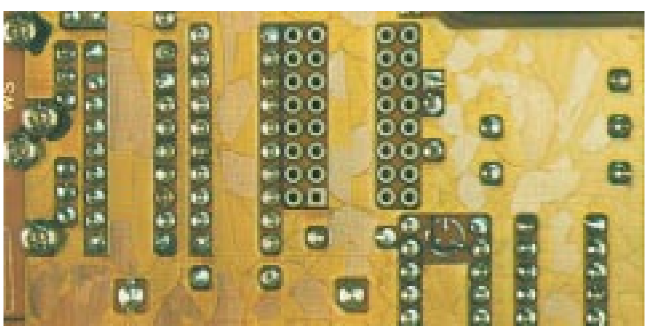

Figure 9-12

9.2.2 Solder Resist Coating - Voids and Blisters

During the solder assembly operation, the resist prevents solder bridging. Blistering and loose particles of solder resist material are acceptable after the completion of the assembly provided they will not affect other functions in the assembly.

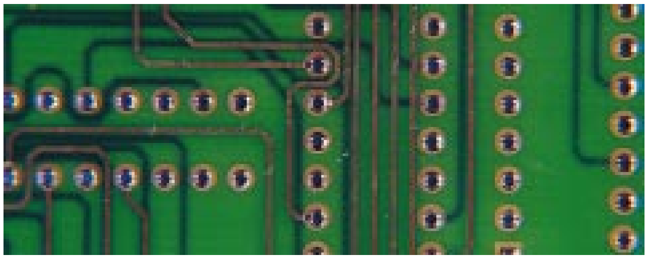

Figure 9-13

Target - Class 1,2,3

- No blisters, scratches, voids or wrinkling evident under solder resist after soldering and cleaning operations.

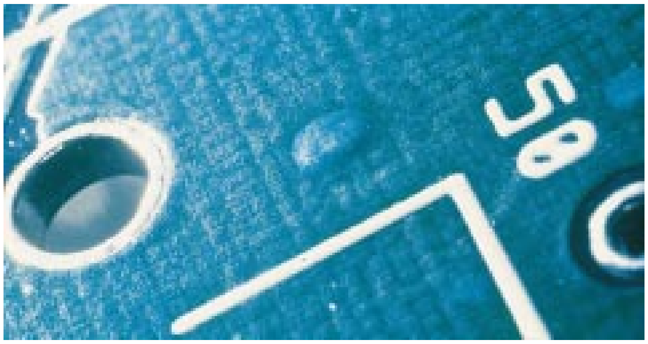

Figure 9-14

Acceptable - Class 1,2,3

- Blisters, scratches, voids that do not bridge adjacent conductors, conductor surfaces or create a hazardous condition which would allow loose resist particles to become enmeshed in moving parts or lodged between two electrically conductive mating surfaces.
- Solder flux, oil or cleaning agents are not trapped under blistered areas.

9.2.2 Solder Resist Coating - Voids and Blisters (cont.)

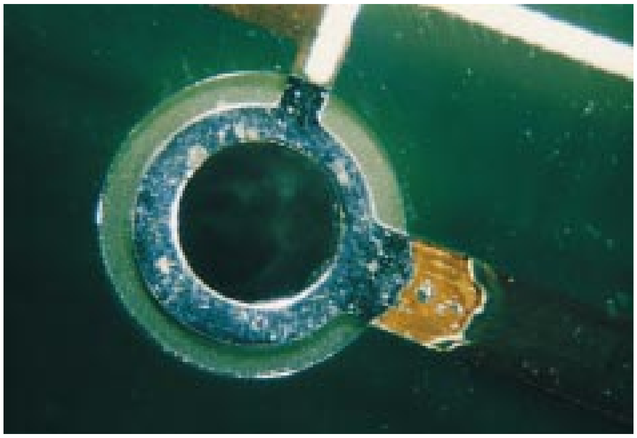

Figure 9-15

Acceptable - Class 1
Defect - Class 2,3

- Blisters/scratches/voids bridge adjacent circuits.
- Blisters/scratches/voids allow film to flake in critical assemblies after a tape test.
- Solder fluxes, oils or cleaning agents are trapped under film.

Process Indicator - Class 2,3

- Blisters/flaking expose bare copper.

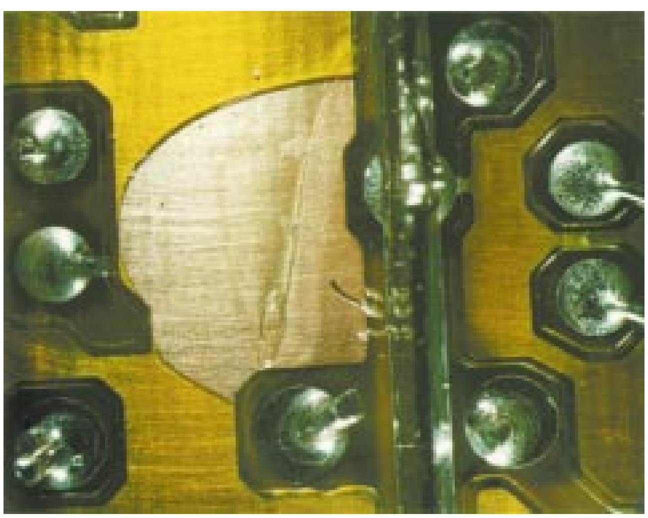

Figure 9-16

Defect - Class 1,2,3

- Loose particles of solder resist material that could affect form, fit or function.
- Blisters/scratches/voids have permitted solder bridges.

9.2.3 Solder Resist Coating - Breakdown

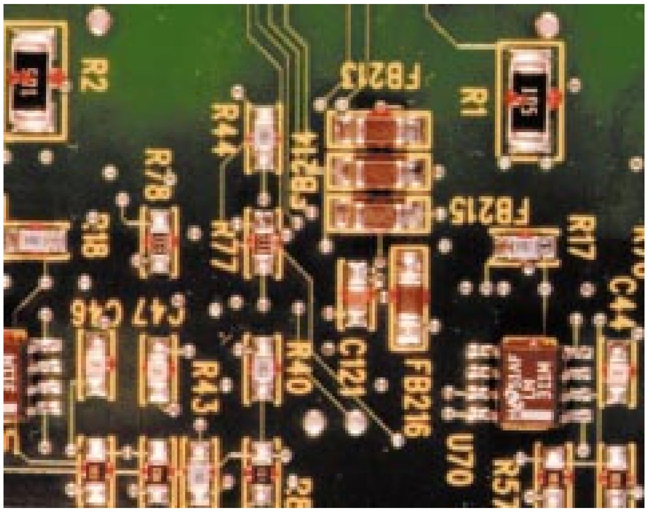

Figure 9-17

Acceptable - Class 1,2,3

- Solder resist surfaces are homogeneous with no flaking or peeling over dielectric areas.

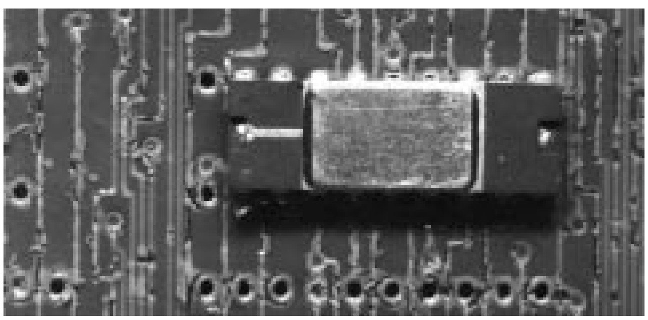

Figure 9-18

Defect - Class 1,2,3

- Solder resist has powdery whitish appearance with possible inclusions of solder metal.

Introduction

The purpose of this section is to help the reader better understand the problem of recognizing laminate defects. In addition to providing detailed drawings and photographs to help identify common laminate defects, this section also provides acceptance criteria for the presence of measles on the board assembly.

This section is based on the requirements of IPC-A-600. The following topics are addressed:

10.1 Introduction

10.1.1 Identification of Defects

The identification of laminate defects can be confusing. To help identify defect conditions, please refer to the following pages where definitions, illustrations, and photographs have been provided which precisely define and identify the following conditions and establish acceptance criteria:

- measling
- crazing
- blistering
- delamination
- weave texture
- weave exposure
- haloing

It is important to note that laminate defect conditions may become apparent when the fabricator receives the material from the laminator, or during the fabrication or assembly of the printed board.

IPC Special Report On Measles

The evidence to date is that even boards with severe measles have functioned adequately over long periods of time and in harsh environments. In fact, the IPC has no data that shows that a measled board (which has no other serious defects) has failed. Refer to IPC-A-600.

10.2 Laminate Damage

10.2.1 Laminate Damage – Measling and Crazing

This is an inherent condition in the laminate caused during processing the board or assembly.

Measling or crazing that occurs as a result of an assembly process (e.g., use of press fit pins, reflow soldering, etc.) will usually not propagate further.

Acceptable - Class 1,2,3

- The only criteria for measling and crazing is that the assembly is functional, as determined through performance testing or dielectric resistance measurements.

Note: Conditions other than measling or crazing should be considered on an individual case or program basis.

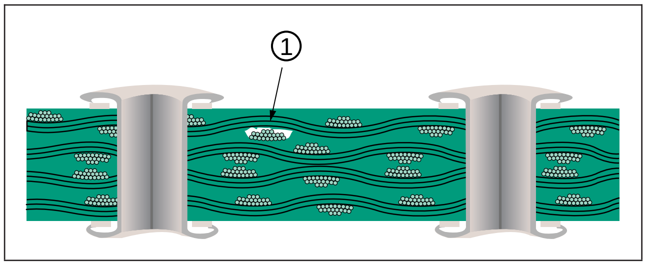

Figure 10-1
1. Measling

Measling – An internal condition occurring in laminated base material in which the glass fibers are separated from the resin at the weave intersection. This condition manifests itself in the form of discrete white spots or crosses below the surface of the base material, and is usually related to thermally induced stress.

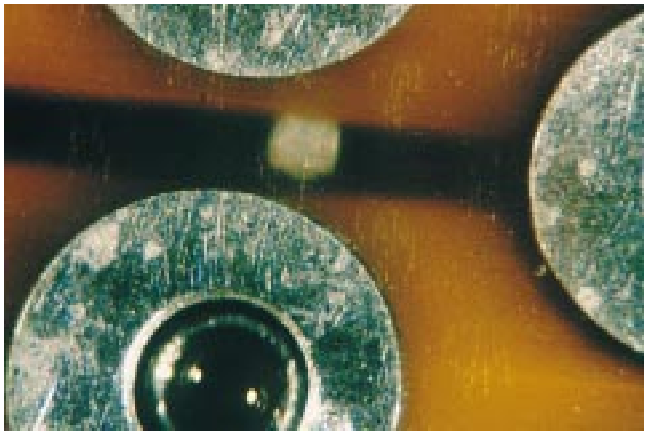

Figure 10-2

10.2.1 Laminate Damage – Measling and Crazing (cont.)

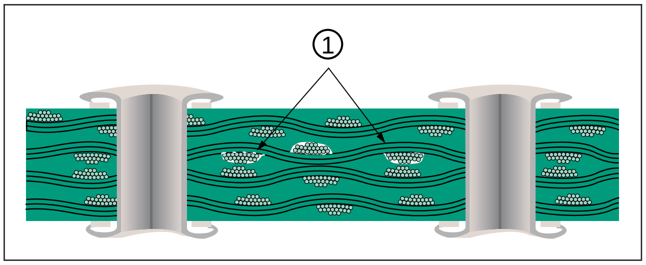

Figure 10-3
1. Crazing

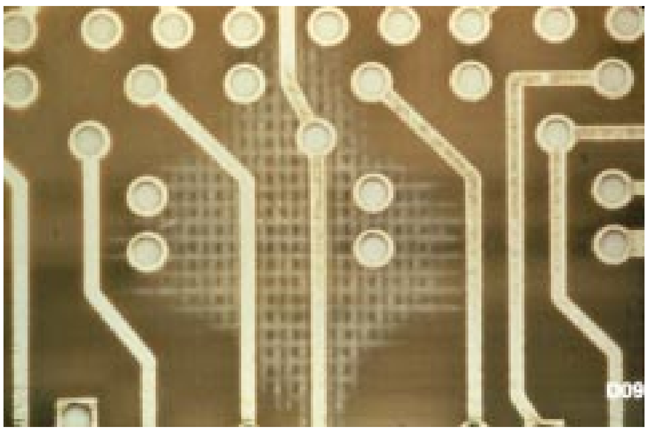

Figure 10-4

Crazing – An internal condition occurring in laminated base material in which the glass fibers are separated from the resin at the weave intersections. This condition manifests itself in the form of connected white spots or crosses below the surface of the base material and is usually related to mechanically induced stress.

10.2.2 Laminate Damage – Blistering and Delamination

In general, delamination and blistering occurs as a result of an inherent weakness of the material or process. Delamination or blistering between nonfunctional areas and functional areas may be acceptable provided that the imperfections are nonconductive and that other criteria are met.

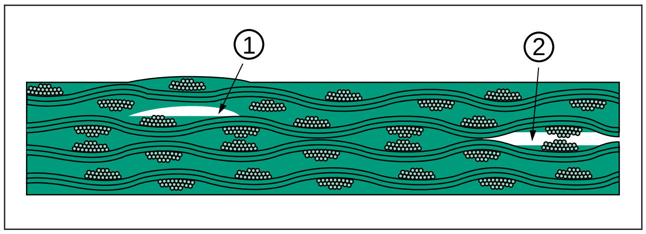

Figure 10-5
1. Blistering
2. Delamination

Blistering – Delamination in the form of a localized swelling and separation between any of the layers of a lamination base material, or between base material and conductive foil or protective coating.

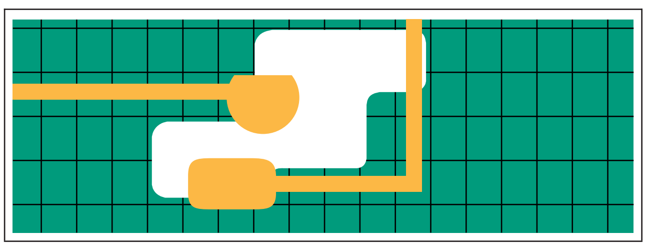

Figure 10-6

Delamination – A separation between plies within a base material, between a base material and a conductive foil or any other planar separation with a printed board.

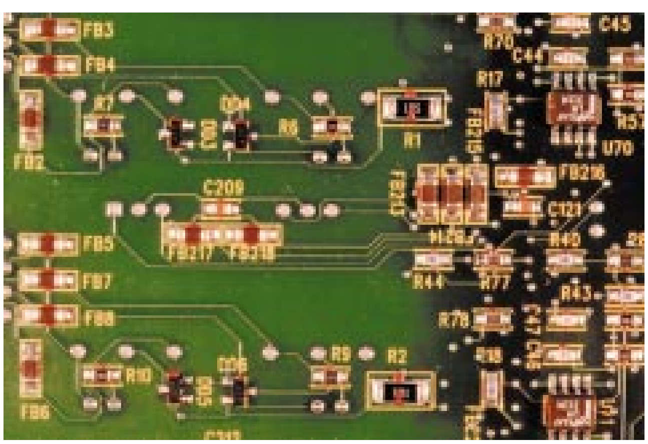

Figure 10-7

Target - Class 1,2,3

• No blistering or delamination.

10.2.2 Laminate Damage – Blistering and Delamination (cont.)

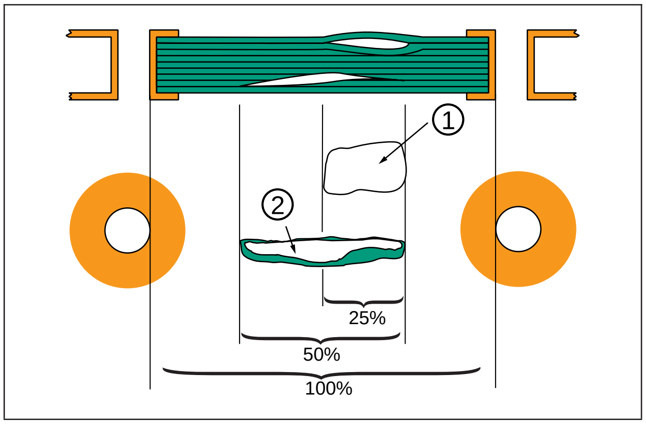

Figure 10-8

1. <25% Blistering/delamination
2. >25% Blistering/delamination; blistering/delamination between plated-through holes

Acceptable - Class 1

- The blistering/delamination does not bridge more than 25% of the distance between plated-through holes or internal conductors.

Defect - Class 1

- Blister/delamination exceeds 25% of the distance between plated-through holes or internal conductors.

Defect - Class 2,3

- Any evidence of blistering/delamination between plated-through holes or internal conductors.

10.2.2 Laminate Damage – Blistering and Delamination (cont.)

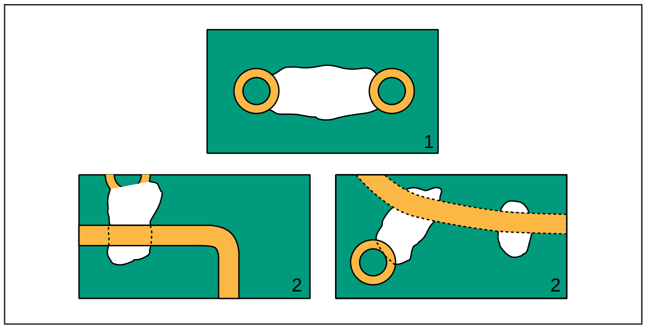

Figure 10-9

Figure 10-10

Figure 10-11

Defect - Class 1,2,3

- Blister/delamination bridges between plated-through holes or subsurface conductors.

10.2.3 Laminate Damage – Weave Texture/Weave Exposure

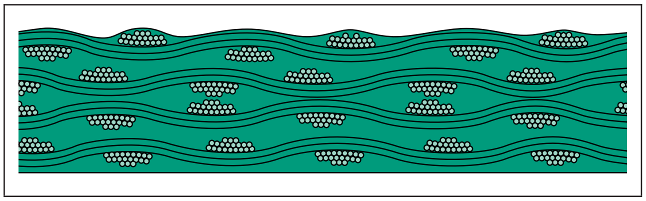

Figure 10-12

Weave Texture – A surface condition of base material in which a weave pattern of glass cloth is apparent although the unbroken fibers are completely covered with resin.

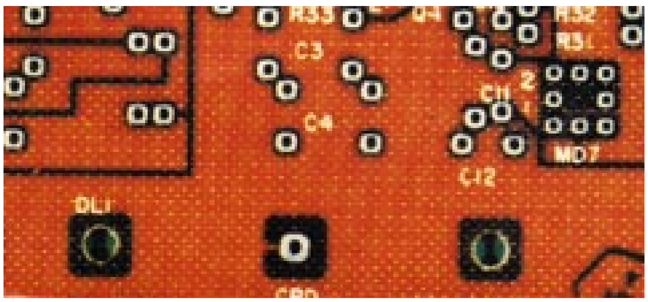

Figure 10-13

Acceptable - Class 1,2,3

- Weave texture is an acceptable condition in all classes but is confused with weave exposure because of similar appearance.

Note: Microsection may be used as a reference for this condition.

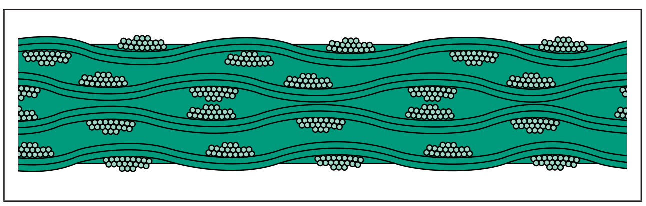

Figure 10-14

Weave Exposure – A surface condition of base material in which the unbroken fibers of woven glass cloth are not completely covered by resin.

Note: Exposed damaged fiber as a result of an assembly process action does not fall within this definition.

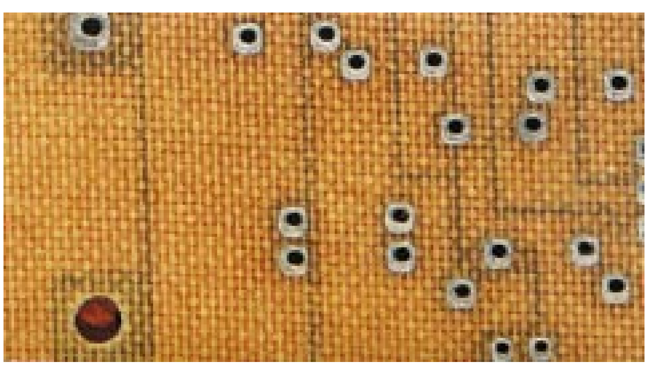

Figure 10-15

Target - Class 1,2,3

- No weave exposure.

Acceptable - Class 1,2,3

- Weave exposure does not reduce the spacing between conductive patterns below specification minimums.

Defect - Class 1,2,3

- Weave exposure reduces the spacing between conductive patterns to less than the minimum electrical clearance.

10.2.4 Laminate Damage – Haloing and Edge Delamination

Haloing – A condition existing in the base material in the form of a light area around holes or other machined areas on or below the surface of the base material.

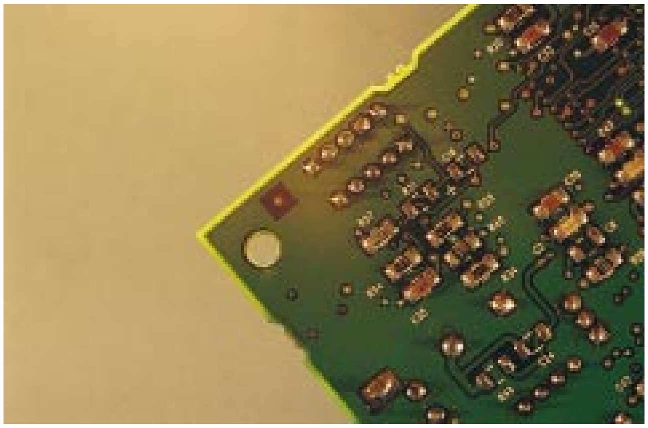

Figure 10-16

Target - Class 1,2,3

- No haloing or edge delamination.

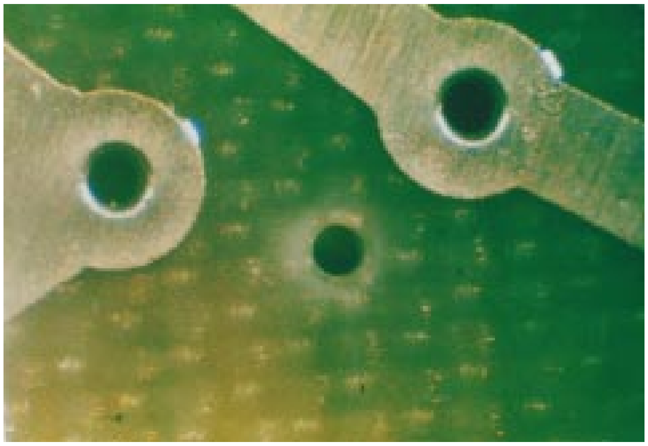

Figure 10-17

Acceptable - Class 1,2,3

- Penetration of haloing or edge delamination does not reduce edge spacing more than 50% of that specified or 2.5 mm [0.0984 in], if none specified.

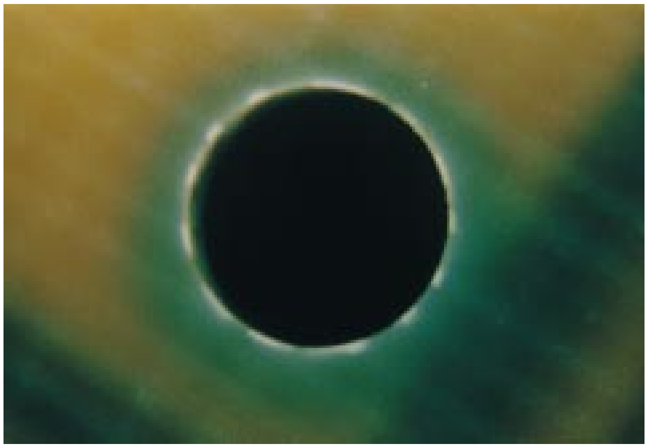

Figure 10-18

10.2.4 Laminate Damage – Haloing and Edge Delamination (cont.)

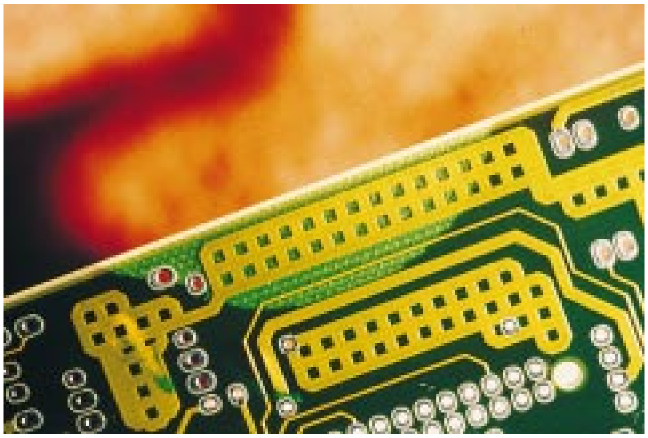

Figure 10-19

Defect - Class 1,2,3

- Penetration of haloing or edge delamination reduces the edge spacing more than 50% of that specified, or more than 2.5 mm [0.0984 in], if none specified.

10.2.5 Laminate Damage – Pink Ring

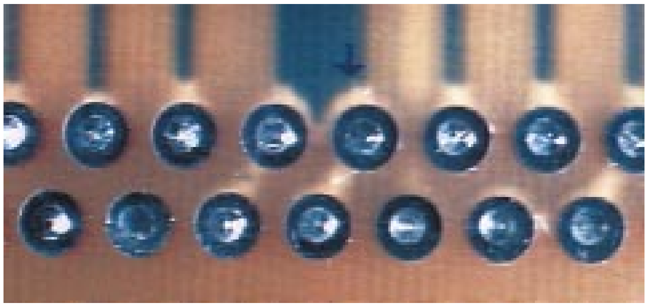

Figure 10-20

Acceptable - Class 1,2,3

- There is no known evidence that pink ring affects functionality. The presence of excessive pink ring may be considered an indicator of process or design variation but is not a cause for rejection. The focus of concern is the quality of the lamination bond.

10.3 Flexible and Rigid-Flex Printed Wiring

The trimmed edge of the flexible printed wiring or the flexible section rigid-flex printed wiring shall be free of burrs, nicks, delamination, or tears in excess of that allowed in the procurement documentation. Minimum edge to conductor shall be specified in the procurement documentation.

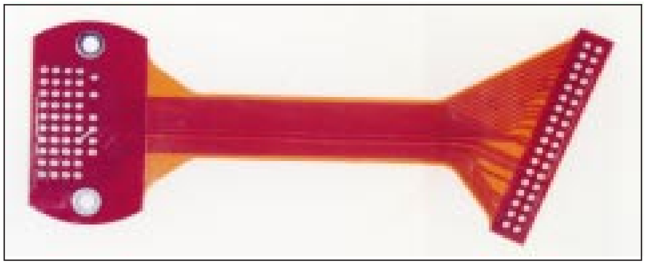

Figure 10-21

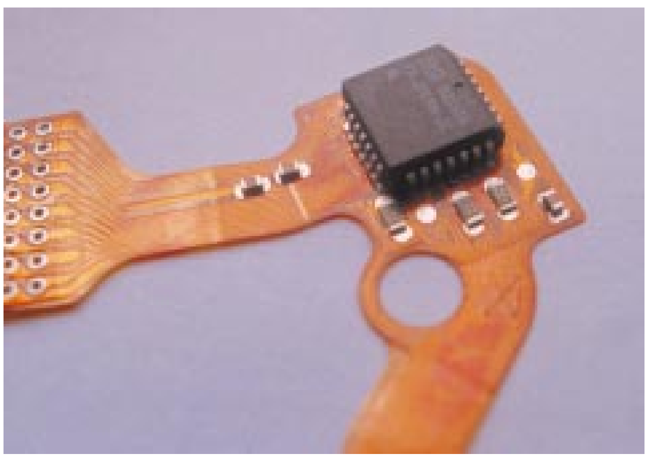

Figure 10-22

Target - Class 1, 2, 3

- Free of nicks and tears. Minimum edge to conductor spacing maintained.
- The trimmed edge of the flexible printed wiring or the flexible section of finished rigid-flex printed wiring is free of burrs, nicks, delamination, and tears.

10.3 Flexible and Rigid-Flex Printed Wiring (cont.)

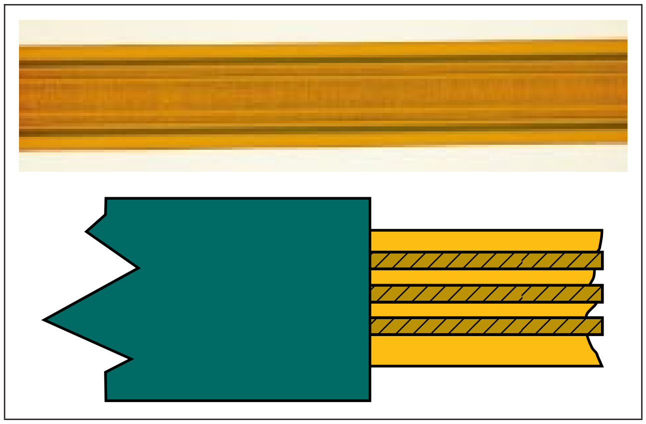

Figure 10-23

Acceptable - Class 1,2,3

- No nicks or tears in excess of that specified in the procurement documentation.
- Nicks and tears that occur as a result of tie-in tabs to facilitate circuit removal shall be as agreed on by the user and supplier.
- Edge to conductor spacing of the flexible portion is within requirements specified on the procurement documentation.
- Nicks or haloing along the edges of the flexible printed wiring, cutouts, and unsupported holes, providing the penetration does not exceed 50% of the distance from the edge to the nearest conductor or 2.5 mm [0.0984 in], whichever is less.

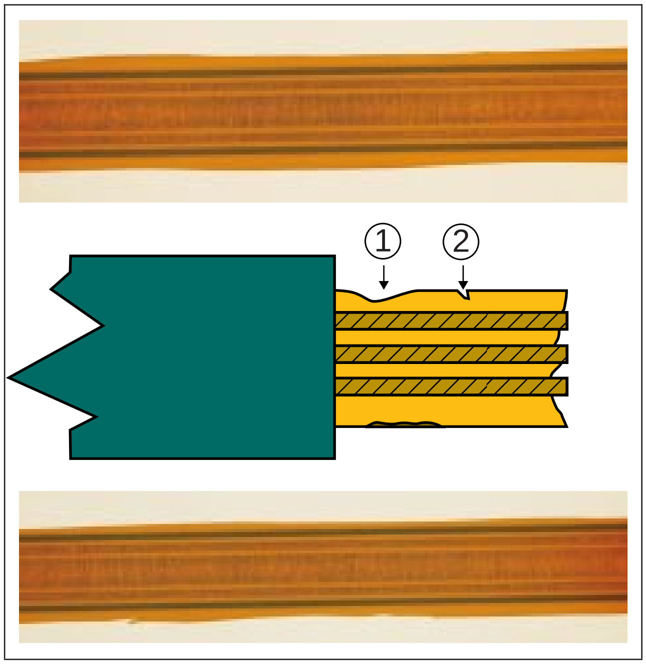

Figure 10-24
1. Nick
2. Tear

Acceptable - As agreed by user and supplier

- When nicks and tears occur as a result of tie-in tabs to facilitate circuit removal, the extent of these imperfections do not exceed the requirements agreed to by user and supplier.

10.4 Solder Resist Discoloration

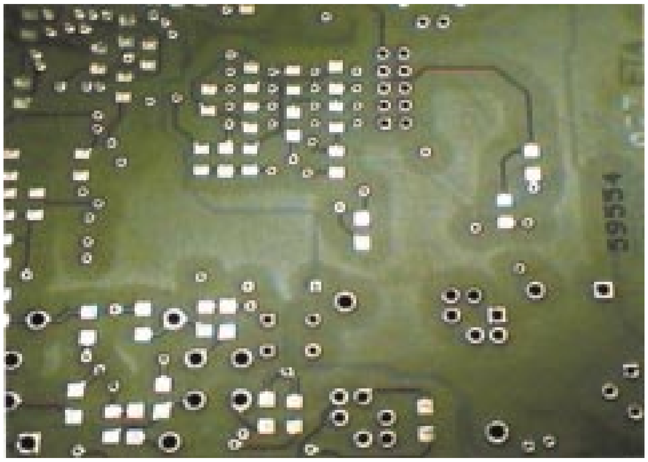

Figure 10-25

Acceptable - Class 1,2,3

• Slight discoloration

Note: Discoloration of the solder resist due to removal/repair of components is acceptable.

10.5 Burns

Figure 10-26

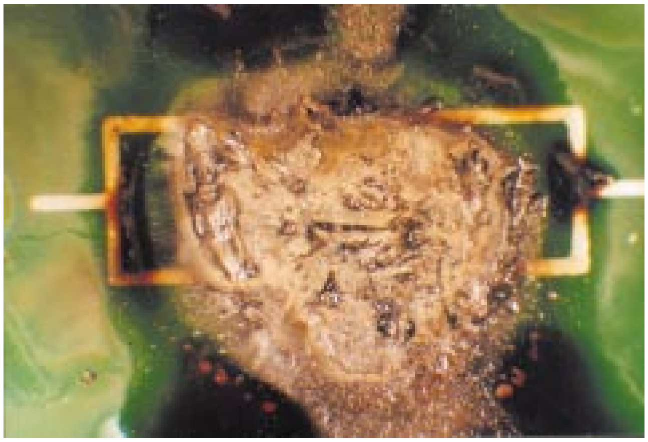

Figure 10-27

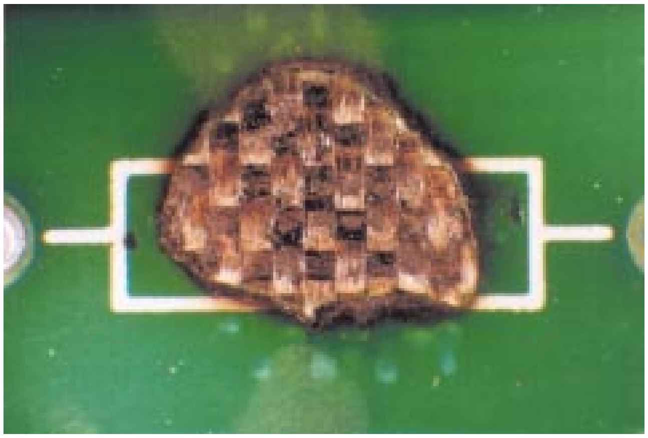

Figure 10-28

Defect - Class 1,2,3

• Burns which physically damage surface or the assembly.

10.6 Bow and Twist

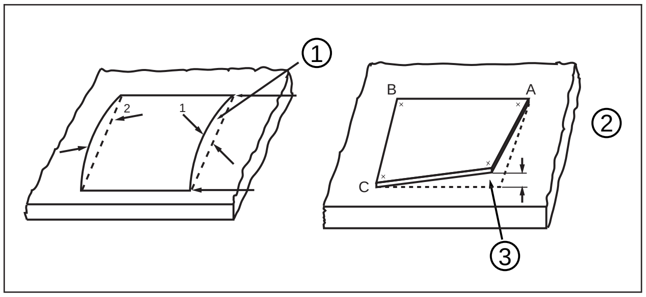

Figure 10-29

1. Bow
2. Points A, B and C are touching base
3. Twist

Acceptable - Class 1,2,3

- Bow and twist does not cause damage during post solder assembly operations or end use. Consider ''Form, Fit and Function'' and product reliability.

Defect - Class - 1,2,3

- Bow and twist causes damage during post solder assembly operations or end use.

Note: Bow and twist after soldering should not exceed 1.5% for through-hole and 0.75% for surface mount printed board applications (See IPC-TM-650, 2.4.22).

10.7 Conductor/Land Damage

10.7.1 Conductor/Land Damage – Reduction in Cross-Sectional Area

IPC-6012 provides the requirements for conductor width and thickness reduction.

Conductor Imperfections – The physical geometry of a conductor is defined by its width x thickness x length. Any combination of defects does not reduce the equivalent cross-sectional area (width x thickness) of the conductor by more than 20% of the minimum value (minimum thickness x minimum width) for Class 2 and 3, and 30% of the minimum value for Class 1.

Conductor Width Reduction – Allowable reduction of the conductor width (specified or derived) due to isolated defects (i.e., edge roughness, nicks, pinholes and scratches) does not exceed 20% of the conductor width for Class 2 and 3, and 30% of the conductor width for Class 1.

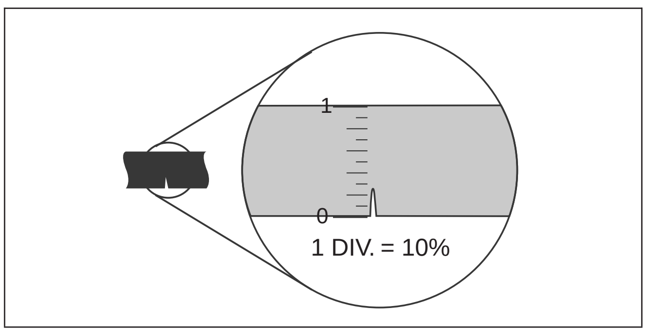

Figure 10-30

Defect - Class 1

- Reduction in width of printed conductors by more than 30%.
- Reduction in width or length of lands by more than 30%.

Defect - Class 2, 3

- Reduction in width of printed conductors by more than 20%.
- Reduction in width or length of lands by more than 20%.

10.7.2 Conductor/Land Damage – Lifted Pads/Lands

When the outer, lower edge of land areas are lifted or separated more than the thickness (height) of the land.

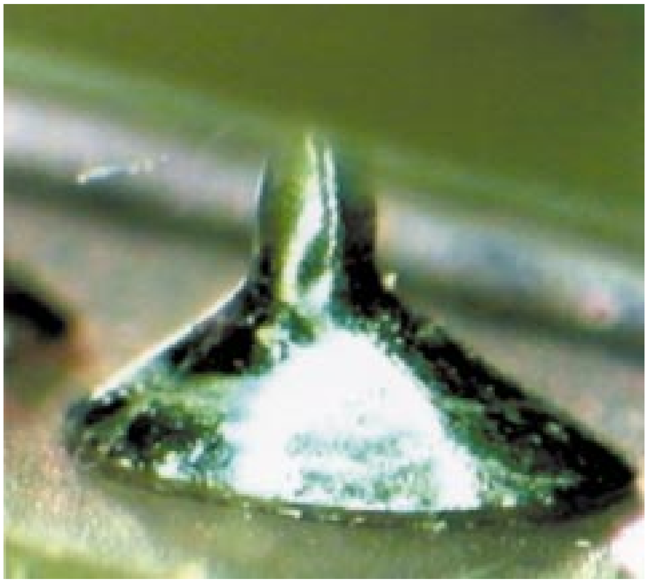

Figure 10-31

Target - Class 1,2,3

- No separation between conductor, pad or land and the laminate surface.

Figure 10-32

Process Indicator - Class 1,2,3

- Separation between outer edge of conductor, pad or land and laminate surface is less than one pad thickness.

Note: Lifted and/or separated land area(s) is typically a result of the soldering process that warrants immediate investigation to determine root cause. Efforts to eliminate and/or prevent this condition should be made.

10.7.2 Conductor/Land Damage – Lifted Pads/Lands (cont.)

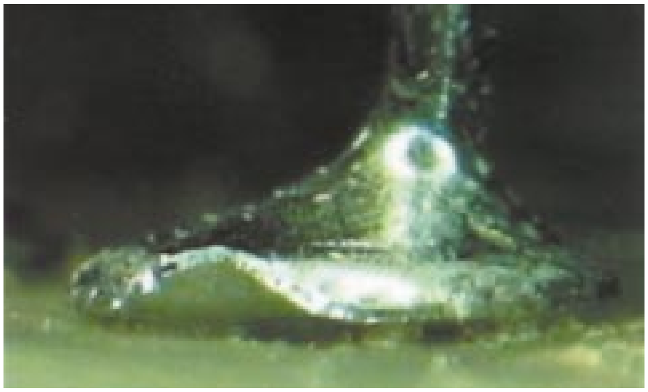

Figure 10-33

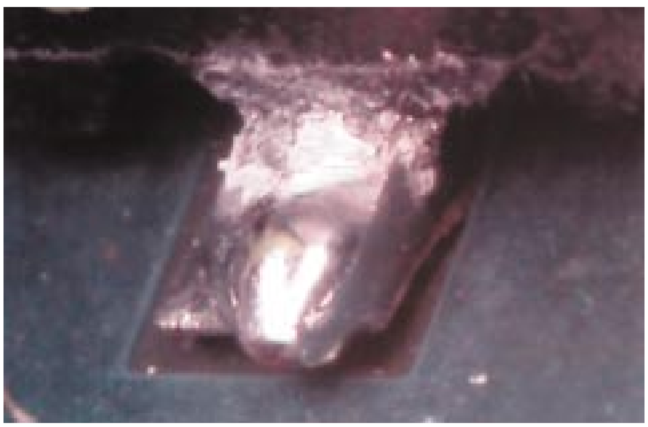

Figure 10-34

Figure 10-35

Defect - Class 1,2,3

- Separation between conductor, pad or land and laminate surface is greater than one pad thickness.

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Discrete Wiring Acceptability Requirements

Discrete wiring refers to a substrate or base upon which discrete wiring techniques are used to obtain electronic interconnections.

Separate visual criteria for each type is depicted in this section.

Discrete Wiring Acceptability Guidelines

The routing and terminating of discrete wires to form point-to-point electrical connections by use of special machines or tools, may be employed to replace or supplement printed conductors on board assemblies. Application may be in planar, two-dimensional or three-dimensional configurations. A summary of various discrete wiring techniques has been documented in the IPC Technical Report, IPC-TR-474, An Overview of Discrete Wiring Techniques. This subject is also covered by IPC-DW-425, Design and End Product Requirements for Discrete Wiring Boards, and IPC-DW-426, Guidelines for Acceptability of Discrete Wiring Assemblies.

This section defines the criteria for acceptability of interconnections produced by some of the important discrete wiring processes in electronic assemblies. The illustrations are presented to depict particular characteristics of the techniques. They are classified in three categories:

1. Mechanically Separable Connections
2. Semi-Permanent Connections
3. Permanent Connections

Further definition of the classification for each discrete wiring technique described herein may be found in the IPC-TR-474.

This section addresses the following subjects:

11.1 Solderless Wrap

Acceptability Requirements

This section establishes visual acceptability criteria for connections made by the solderless wrap method.

It is assumed that the terminal/wire combination has been designed for this type of connection (IPC-DW-425).

The tightness of the wire wrap should be validated by the tool verification process.

It is also assumed that a monitoring system exists using test connections to verify that the operator/tooling combination is capable of producing wraps that meet strip force requirements.

Depending on the service environment, the connecting instructions will specify whether the connection will be conventional or modified.

Once applied to the terminal, an acceptable solderless wrap connection must not be subjected to excessive heat nor have any mechanical operations performed on it.

No attempt to correct a defective connection by reapplying the wrapping tool or by applying other tools is to be made.

The reliability and maintainability advantages of the solderless wrap connection method are such that no repair of a defective wrap by soldering is to be made.

The defective connections must be unwrapped using a special tool (not stripped off the terminal) then a new wire wrapped. New wire must be used for each rewrap, but the terminal may be rewrapped many times.

11.1.1 Solderless Wrap - Number of Turns

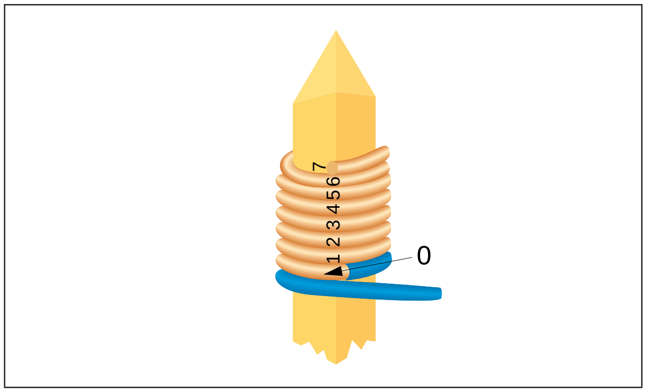

Figure 11-1

Number of Turns

For this requirement, countable turns are those turns of bare wire in intimate contact with the corners of the terminals starting at the first contact of bare wire with a terminal corner and ending at the last contact of bare wire with a terminal corner (see Table 11-1).

Table 11-1 Minimum Turns of Bare Wire

Wire Gauge	Turns
30	7
28	7
26	6
24	5
22	5
20	4
18	4

The target condition is a half (50%) turn more than that shown in the table. A modified wrap is required for Class 3. It has an additional amount of insulated wire wrapped to contact at least three corners of the terminal.

Maximum turns of bare and insulated wire is governed only by tooling configuration and space available on the terminal.

11.1.2 Solderless Wrap - Turn Spacing

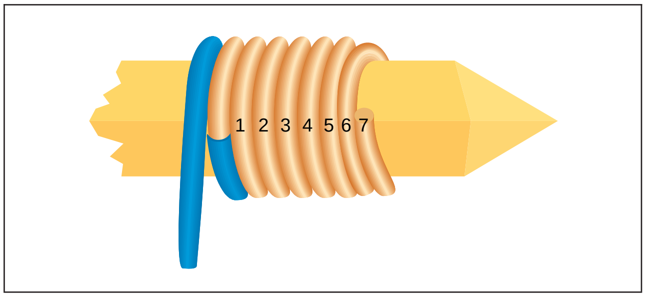

Figure 11-2

Target - Class 1,2,3

• No space between any turns.

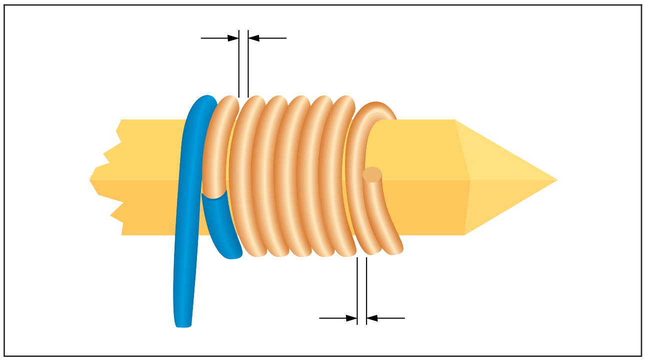

Figure 11-3

Acceptable - Class 1

• No space over one wire diameter.

Acceptable - Class 2

• No space over 50% diameter of wire within countable turns.

• No space over one wire diameter elsewhere.

Acceptable - Class 3

• No more than three turns spaced apart.

• Not more than 50% wire diameter apart.

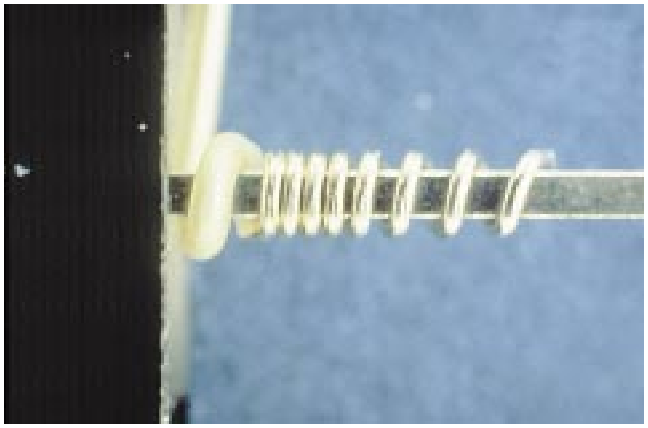

Figure 11-4

Defect - Class 1

• Any space over one wire diameter.

Defect - Class 2

• Any space over half wire diameter within countable turns.

Defect - Class 3

• Any space more than half wire diameter.

• More than three spaces any size.

11.1.3 Solderless Wrap - End Tails, Insulation Wrap

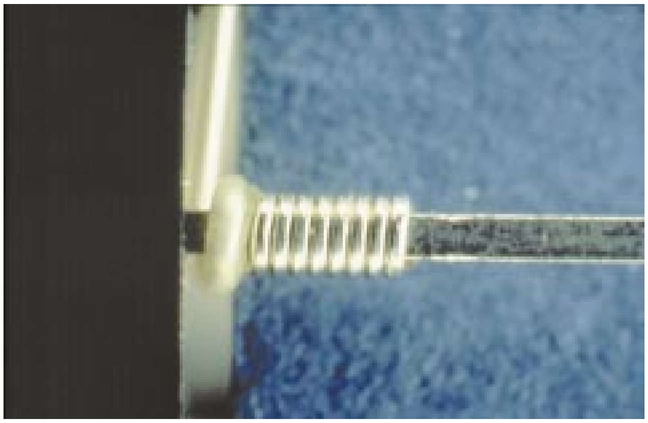

Figure 11-5

Target - Class 1,2

- End tail does not extend beyond outer surface of wrap.
- Insulation reaches terminal.

Target - Class 3

- End tail does not extend beyond outer surface of wrap with insulation modified wrap (see 11.1.1).

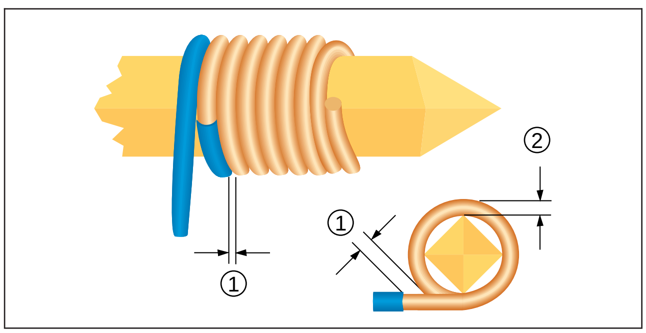

Figure 11-6
1. Insulation clearance
2. Wire diameter (viewed from bottom)

Acceptable - Class 1

- Insulation end does not permit shorting to other noncommon pins or wires.
- End tail extends beyond outer surface of wrap, but does not violate electrical clearance requirements.

Acceptable - Class 2

- Insulation end meets clearance requirements to other circuitry.
- End tail does not extend more than 3 mm [0.12 in] from outer surface of wrap.

Acceptable - Class 3

- End tail projects no more than one wire diameter from outer surface of wrap.
- Insulation must contact minimum of three corners of post.

Process Indicator - Class 3

- Insulation does not contact three corners of the post.

11.1.3 Solderless Wrap - End Tails, Insulation Wrap (cont.)

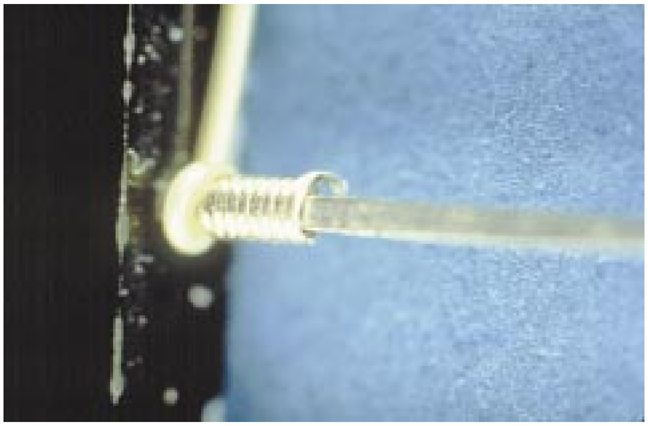

Figure 11-7

Acceptable - Class 1
Defect - Class 2,3

• End tail is greater than 3.0 mm [0.12 in].

Defect - Class 3

• End tail is greater than one wire diameter.

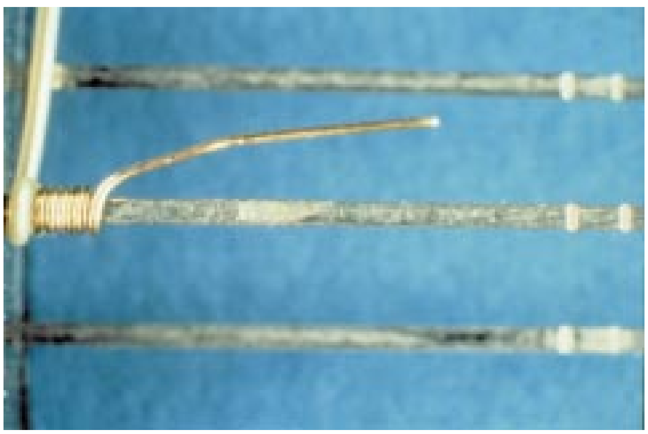

Figure 11-8

Defect - Class 1,2,3

• End tail violates minimum electrical clearance.

11.1.4 Solderless Wrap - Raised Turns Overlap

Raised turns are squeezed out of the helix, therefore no longer have intimate contact with the terminal corners. Raised turns may overlap or override other turns.

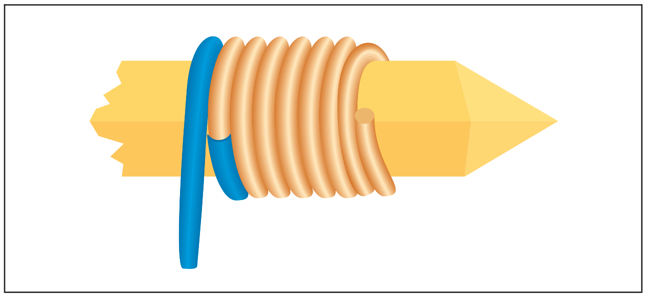

Figure 11-9

Target - Class 1,2,3

- No raised turns.

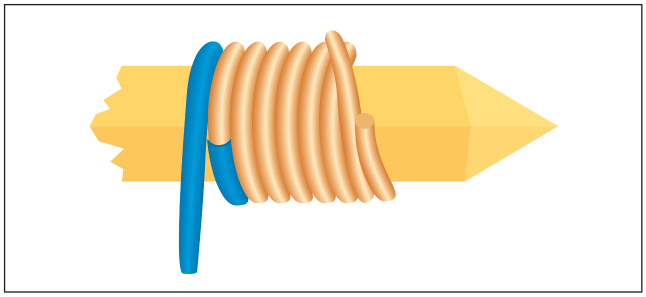

Figure 11-10

Acceptable - Class 1

- Raised turns anywhere provided remaining total turns still have intimate contact and meet minimum turns requirement.

Acceptable - Class 2

- No more than half turn raised within countable turns, any amount elsewhere.

Acceptable - Class 3

- No raised turns within countable turns, any amount elsewhere.

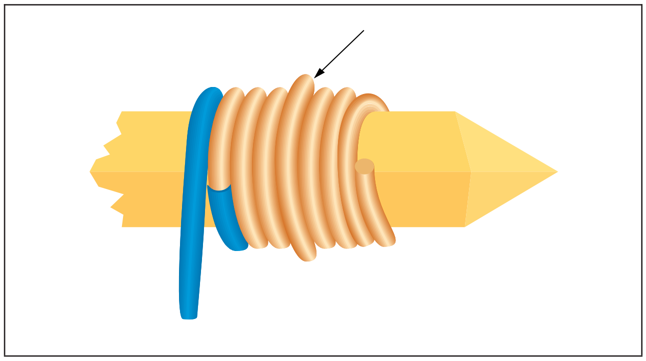

Figure 11-11

Defect - Class 1

- Remaining total turns that still have intimate contact do not meet minimum turn requirements.

Defect - Class 2

More than half raised turn within countable turns.

Defect - Class 3

- Any raised turns within countable turns.

11.1.5 Solderless Wrap - Connection Position

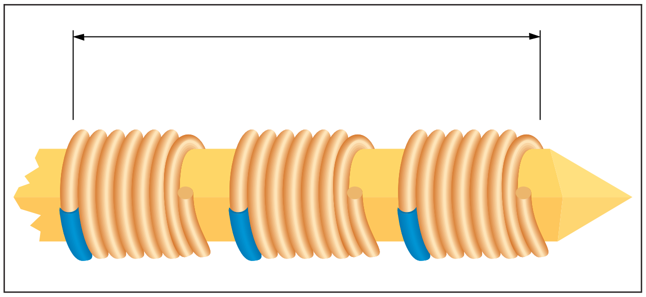

Figure 11-12

Target - Class 1,2,3

- All turns of each connection on working length of terminal.
- Visible separation between each connection.

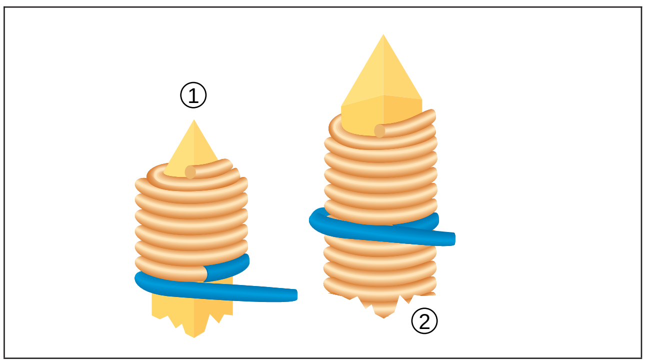

Figure 11-13
1. Wrap extends above working length
2. Insulation turn overlaps previous wrap

Acceptable - Class 1,2

- Extra turns of bare wire or any turns of insulated wire (whether or not for modified wrap) beyond end of working length of terminal.

Acceptable - Class 1

- Extra turns of bare wire or any turns of insulated wire overlap a preceding wrap.

Acceptable - Class 2

- Turns of insulated wire only overlaps a preceding wrap.

Acceptable - Class 3

- Wraps may have an insulated wire overlap the last turn of uninsulated wire.
- No turns of bare or insulated wire beyond either end of working length.

11.1.5 Solderless Wrap - Connection Position (cont.)

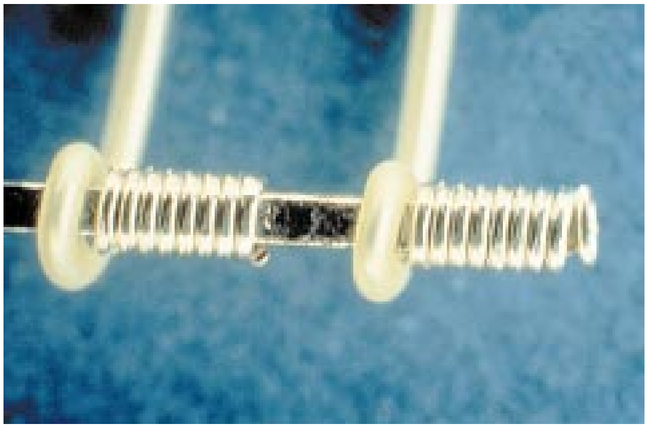

Figure 11-14

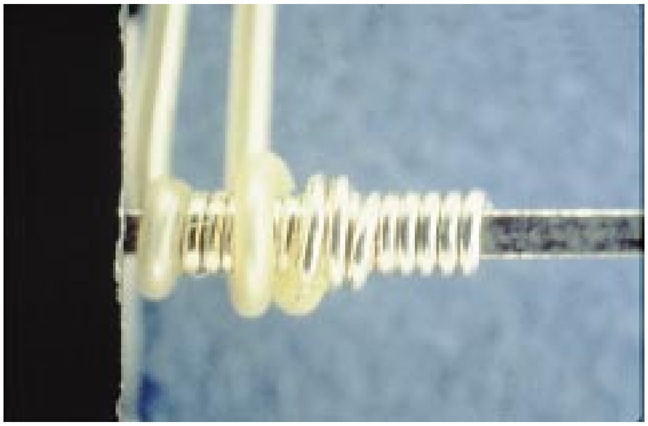

Figure 11-15

Defect - Class 1,2,3

- Any countable turns of bare wire off either end of working length.
- Any countable minimum turns of bare wire overlapping wire turns of a preceding connection.

11.1.6 Solderless Wrap - Wire Dress

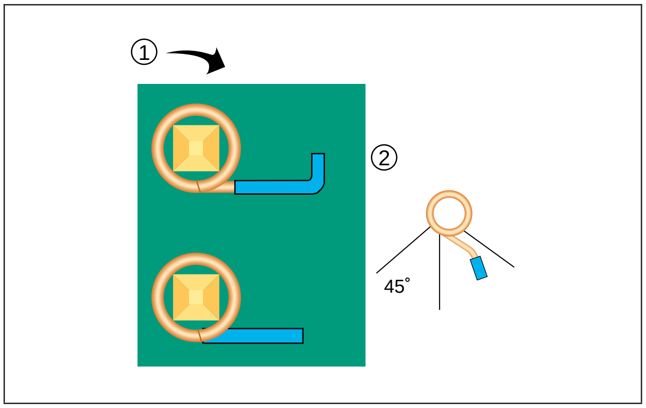

Figure 11-16
1. Direction of turns
2. Proper radius

Acceptable - Class 1,2,3

- The dress of wire needs to be oriented so that force exerted axially on the wire will not tend to unwrap the connection, or to relieve the bite of wire on the corners of the terminal post. This requirement is satisfied when the wire is routed so as to cross the 45° line as shown.

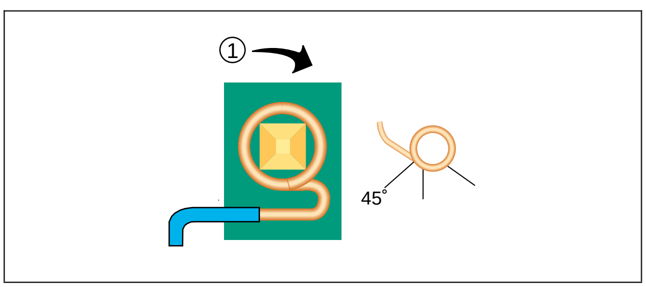

Figure 11-17
1. Direction of turns

Defect - Class 1,2,3

- Axially exerted external forces on the wrap will cause the wrap to unwind or loosen the wire bite at the post corners.

11.1.7 Solderless Wrap - Wire Slack

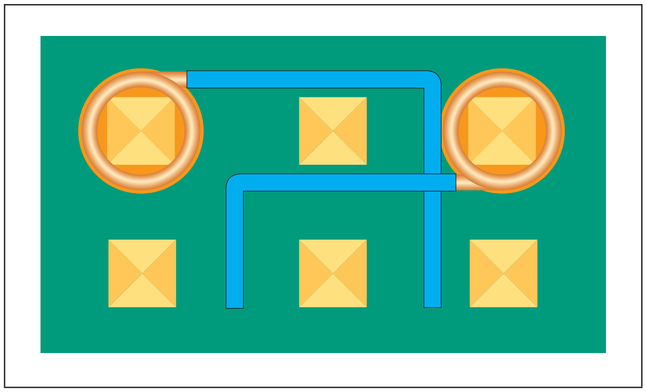

Figure 11-18

Acceptable - Class 1,2,3

- Wiring needs to have sufficient slack so that it will not pull around corners of the other terminal posts or bridge and load other wires.

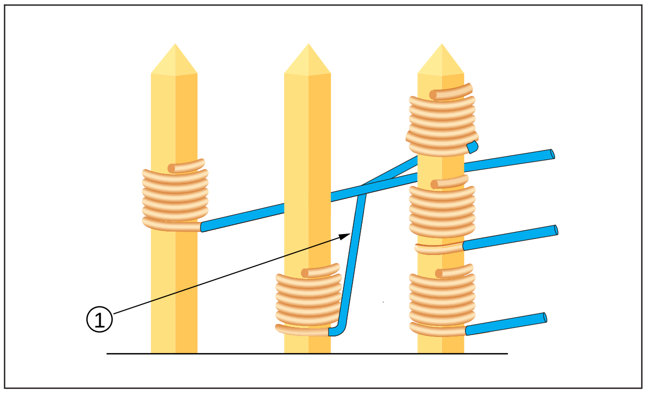

Figure 11-19
1 Wire crossing

Defect - Class 1,2,3

- Insufficient wire slack causing:
  - Abrasion between wire insulation and wrap post.
  - Tension on wires between wrap post causing distortion of posts.
  - Pressure on wires that are crossed by a taut wire.

11.1.8 Solderless Wrap - Plating

Plating

Copper wire used for solderless wrap is normally plated with tin or silver to improve connection reliability and minimize subsequent corrosion.

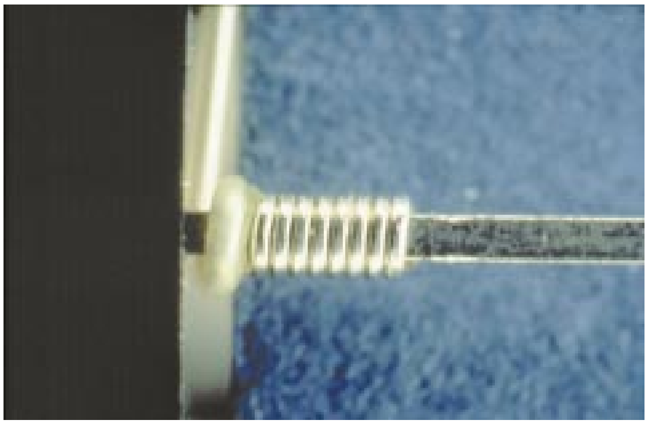

Figure 11-20

Target - Class 1,2,3

• After wrapping, uninsulated wire has no exposed copper.

Acceptable - Class 1

• Exposed copper.

Acceptable - Class 1,2

• Up to 50% of countable turns show exposed copper.

Defect - Class 2

• More than 50% of countable turns show exposed copper.

Defect - Class 3

• Any exposed copper (last half turn and wire end excluded).

11.1.9 Solderless Wrap - Damaged Insulation & Terminals

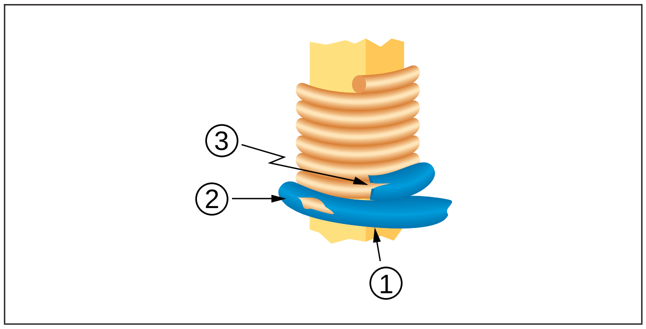

Figure 11-21
1. Initial corner
2. Insulation split
3. Insulation cut or frayed

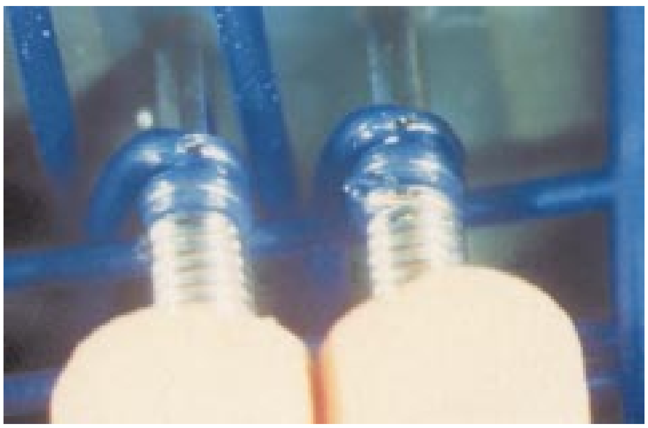

Figure 11-22

Acceptable - Class 1,2,3

- After initial contact with post:
  - Insulation damage.
  - Splits.
  - Cut or fraying on the wrap.

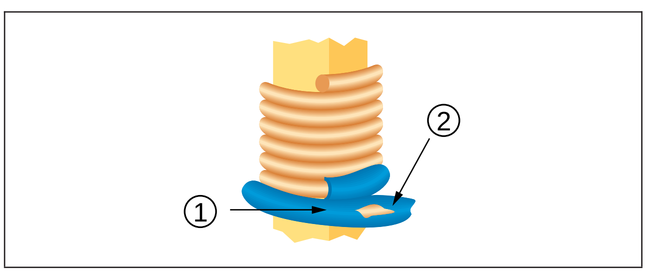

Figure 11-23
1. Initial contact corner
2. Split insulation, etc., between wrap terminal. Conductor is exposed.

Defect - Class 1,2,3

- Minimum electrical clearance violated.

Defect - Class 2,3

- Splits, cuts or fraying of insulation between wrap terminals prior to initial contact corner of post.
- Spacing requirements are violated.

11.1.10 Solderless Wrap – Conductor Damage

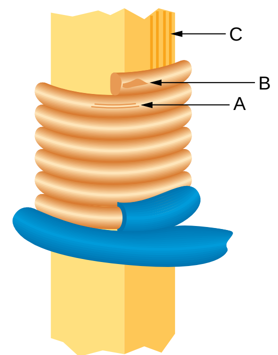

Figure 11-24

Acceptable - Class 1,2,3

A. Finish on the wire is burnished or polished (slight tool marks).

B. The top or last turn damaged from the wrap tool such as nicks, scrapes, gouges, etc., not exceeding 25% of wire diameter.

C. Damage to terminal caused by tool such as burnishing, scraping, etc.

Acceptable - Class 1,2
Defect - Class 3

• Base metal is exposed on terminal.

11.2 Jumper Wires

This section establishes visual acceptability criteria for the installation of discrete wires used to interconnect components where there is no continuous printed circuit. IPC-T-50 divides these wires into two types, depending on whether they are part of the original design or a modification/repair. The following definitions are from IPC-T-50.

Haywire – A discrete electrical connection that is added to a printed board in order to modify the basic conductor pattern formed on the board.

Jumper Wire – A discrete electrical connection that is part of the original design and is used to bridge portions of the basic conductor pattern formed on a printed board.

The requirements relative to wire type, wire routing, staking and soldering requirements are the same for both haywires and jumper wires. For the sake of simplicity only the more common term, jumper wires, is used in this section, however these requirements would apply to both haywires and jumper wires.

The following items are addressed:

- Wire type
- Wire routing
- Adhesive staking of wire
- Solder termination

They may be terminated in plated holes, and/or to terminal standoffs, conductor lands, and component leads.

Jumper wires are considered as components and are covered by an Engineering instruction document for routing, termination, staking and wire type.

Keep jumper wires as short as practical and do not route over or under other replaceable components. Design constraints such as real estate, availability and minimum electrical clearance, need to be taken into consideration when routing or staking wires. Jumper wires 25 mm [0.984 in] maximum in length whose path does not pass over conductive areas and do not violate the designed spacing requirements may be uninsulated. Insulation, when required on the jumper wires, needs to be compatible with conformal coating.

11.2.1 Jumper Wires - Wire Selection

The following considerations are to be made when selecting wires for jumpers:

1. Wire is insulated if greater than 25 mm [0.984 in] in length or is liable to short between lands or component leads.
2. Silver plated stranded wire should not be used. Under some conditions corrosion of the wire can occur.
3. Select the smallest diameter wire that will carry the required current needs.
4. The insulation of the wire should withstand soldering temperatures, have some resistance to abrasion, have a dielectric resistance equal to or better than the board insulation material.
5. Recommended wire is solid insulated copper wire, tin lead plated.
6. Chemical solutions, pastes, and creams used to strip solid wires do not cause degradation to the wire.

11.2.2 Jumper Wires - Wire Routing

Unless otherwise specified by high speed/high frequency requirements, route jumper wires the shortest route in straight legs as possible, avoiding test points, to points of termination. Allow enough length for routing, stripping and attachment.

Jumper wire routing on assemblies having the same part number should be the same pattern.

Routing needs to be documented for each part number and followed without deviation.

On the primary side, do not allow jumper wires to pass over or under any component, however, they may pass over parts such as thermal mounting plates, brackets and components that are bonded to the PWB.

On the primary side jumpers may pass over solder lands if sufficient slack is provided so they can be moved away from the solder land for component replacement.

Contact with heat sinks specific to high temperature generating components must be avoided.

On secondary side, except for connectors at the edge of the board, do not pass jumpers through component foot prints unless the layout of the assembly prohibits the routing in other areas.

On the secondary side, do not pass jumpers over patterns or vias used as a test point.

11.2.2.1 Jumper Wires - Wire Routing - Component Side

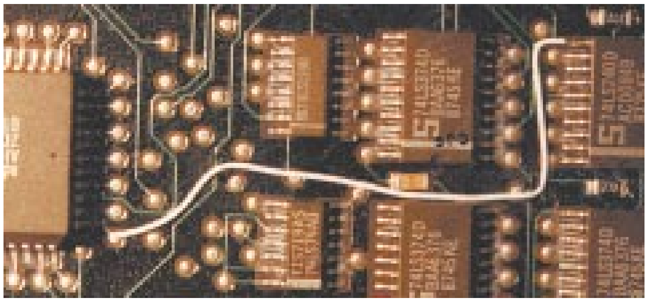

Figure 11-25

Target - Class 1,2,3

- Wire routed shortest route.
- Wire does not pass over or under component.
- Wire does not pass over land patterns or vias used as test points.

Acceptable - Class 1
Process Indicator - Class 2,3

- Sufficient slack in wire to allow relocation from lands during component replacement.

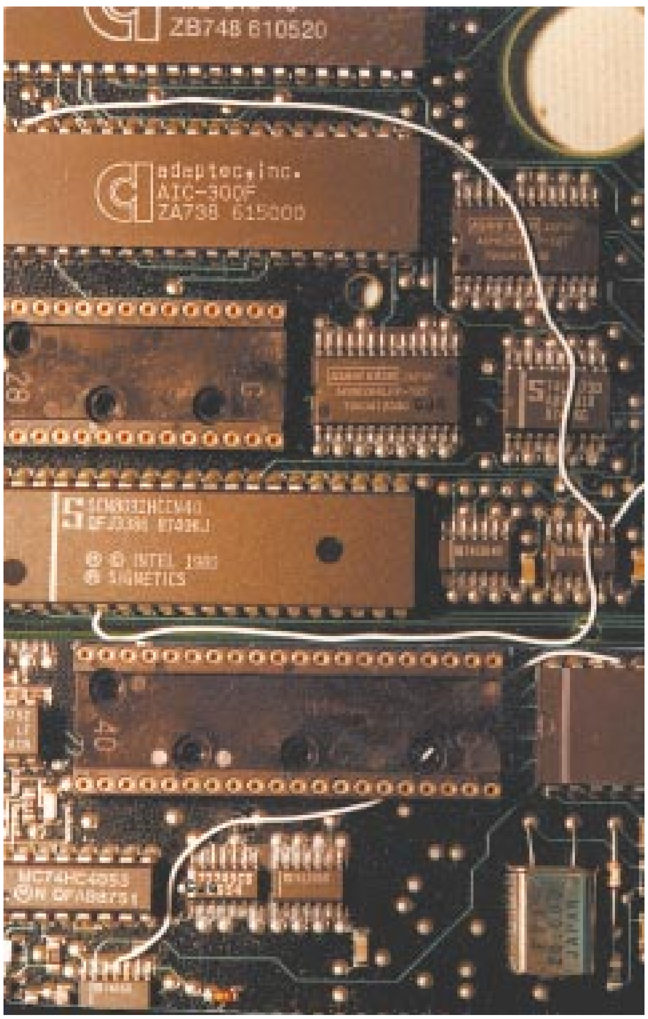

Figure 11-26

Acceptable - Class 1
Defect - Class 2,3

- Wire routed under or over components.

11.2.2.2 Jumper Wires - Wire Routing - PTH Termination Side

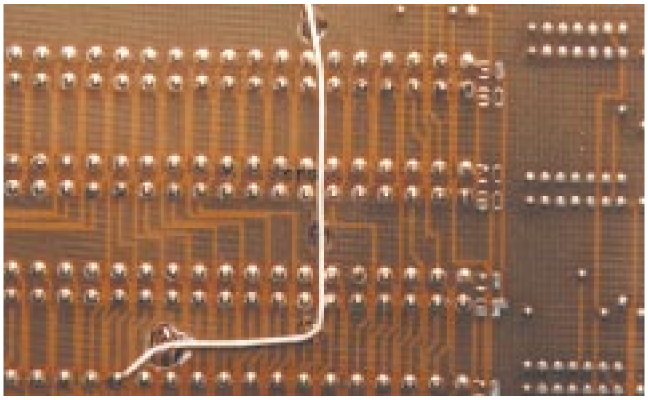

Figure 11-27

Target - Class 1,2,3

• Wire does not cross component footprint or lands.

Acceptable - Class 1,2,3

• Unavoidable crossing of component footprint area.

• Lands not covered by wire.

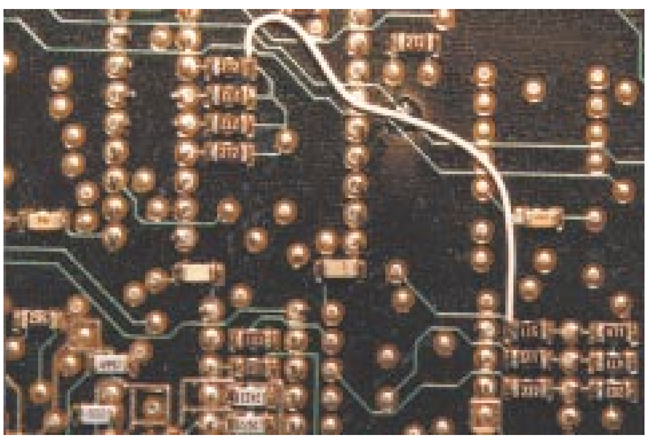

Figure 11-28

Acceptable - Class 1,2,3

• Sufficient slack in wire to allow relocation from unavoidable lands during component replacement or test.

Acceptable - Class 1
Process Indicator - Class 2,3

• Wire crosses component footprint and lands.

11.2.3 Jumper Wires - Wire Staking

Jumper wires may be staked to the base material (or integral thermal mounting plate or hardware) by adhesive or tape (dots or strips). When adhesive is used, it is to be mixed and cured in accordance with the manufacturer's instructions. All adhesive must be fully cured before acceptance. Consider the end-use product environment as well as subsequent process compatibility when selecting the appropriate staking method.

Spot bond so that the stake fillet is sufficient to secure the wire with no excessive spillover onto adjacent lands or components.

Staking is not to be on a removable or socketed component. Where design constraints are an obstacle, staking is to be discussed with the customer.

Jumper wires are not to be staked to, or allowed to touch, any moving parts. Wires are staked within the radius of each bend for each change of direction.

Wires and staking tape/adhesive do not overhang the board edge.

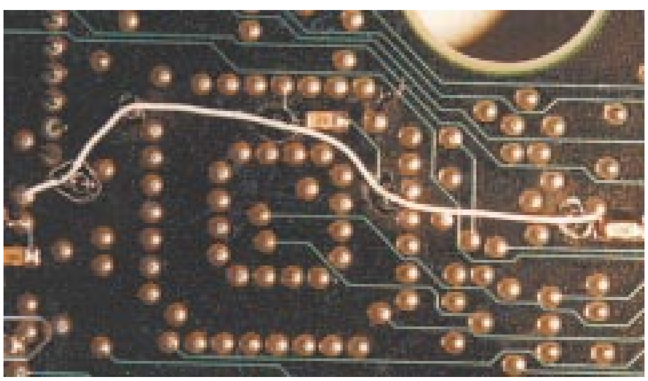

Figure 11-29

Acceptable - Class 1,2,3

- Jumper wires are staked at intervals as specified by engineering documentation or:
  - At all changes of direction to restrict movement of wire.
  - As close to the solder connection as possible.
- The wire is not so loose that it can extend above the height of adjacent components when pulled taut.

11.2.3 Jumper Wires - Wire Staking (cont.)

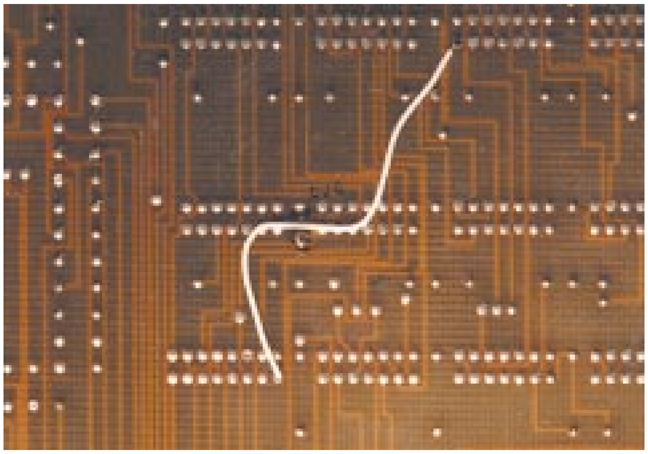

Figure 11-30

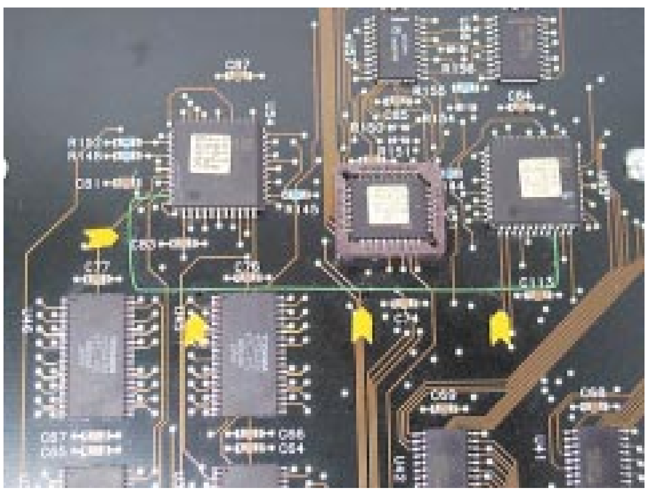

Figure 11-31

Acceptable - Class 1
Defect - Class 2,3

- The wire is loose and can extend above the height of adjacent components when pulled taut.
- Jumper wires are not staked as specified.

11.2.4 Jumper Wires – Plated-Through Holes

Jumper wires may be attached by any of the following methods. However, the method used for a particular assembly type needs to be defined.

This section is intended to show jumper wire practices that are used in original manufacturing. See IPC-7721 for additional jumper wire information when affecting repairs and modifications.

For jumper wires attached to components other than axial leaded, lap solder the wire to the component lead. Assure the solder connection length and insulation clearance meet the minimum/maximum acceptability requirements.

11.2.4.1 Jumper Wires – PTH – Lead in Hole

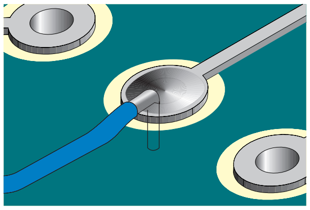

Figure 11-32

Acceptable - Class 1,2,3

- Wires may be soldered into a via hole.

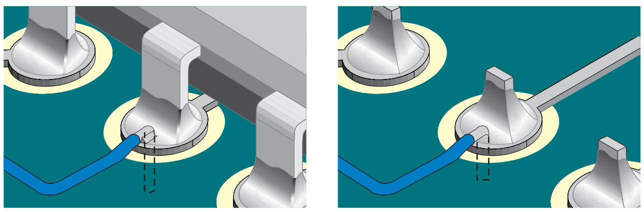

Figure 11-33

Acceptable - Class 1,2
Defect - Class 3

- Wire soldered into plated-through hole with component lead.

11.2.4.2 Jumper Wires – PTH – Wrapped Attachment

The jumper wire ends are attached to component lead projections by wrapping the wire.

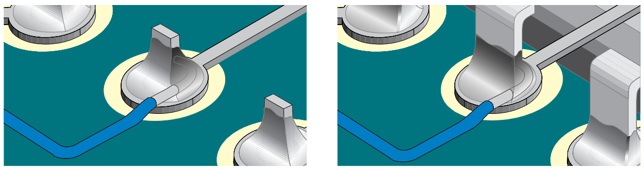

Figure 11-34

Acceptable - Class 1,2,3

- Wire is wrapped a minimum of 90° and soldered to a component lead.
- Acceptable solder connection at wire/lead interface.
- Outline of wire evident in solder.
- No insulation in solder.
- No wire overhanging component termination.

Figure 11-35

Defect - Class 1,2,3

- Wire is wrapped less than 90°.
- Insulation is in the solder connection.
- Wire overhang of the solder termination violates the minimum electrical clearance.

11.2.4.3 Jumper Wires – PTH – Lap Soldered

For jumper wires attached to components other than axial leaded, lap solder the wire to the component lead.

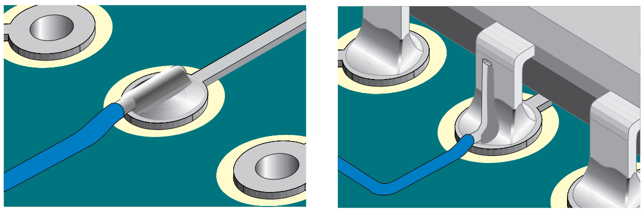

Figure 11-36

Acceptable - Class 1,2,3

- Wire is lap soldered to a component lead a minimum of 75% of lead length.
- Wire is lap soldered to a via surface.
- Acceptable solder connection at wire/lead interface.
- Outline of wire evident in the solder.
- No insulation in solder.
- No wire overhanging or extending beyond land or above component lead.

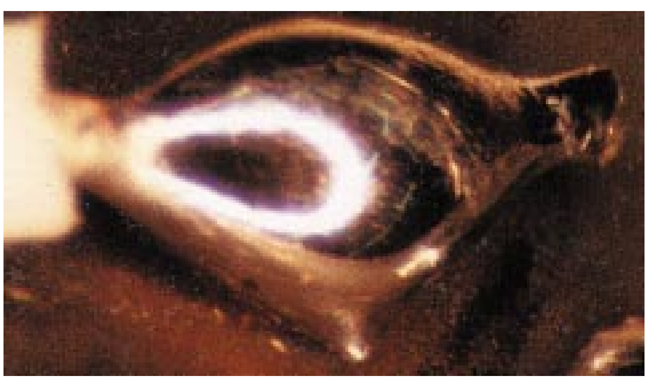

Figure 11-37

Figure 11-38

Defect - Class 1,2,3

- Wire that is lap soldered is less than 75% of the lead length.
- Insulation is in the solder.
- Wire overhangs the land and/or violates minimum electrical clearance.

11.2.5 Jumper Wires - SMT

There is no adhesive on component bodies, leads or lands. Adhesive deposits do not obscure solder connections.

For all lap solder connections described in this section the following conditions are acceptable:

Insulation clearance (C) does not permit shorting to noncommon conductors or violate minimum electrical clearance.

No wire insulation is in the solder.

Proper wetting of jumper wire and lead/pad.

Wire contour is visible in the solder connection or end of wire is visible.

No fractures in solder connection.

Note: For applications of high frequency (i.e., RF), lead extending above the top of the component could present problems.

11.2.5.1 Jumper Wires – SMT – Chip and Cylindrical End Cap Components

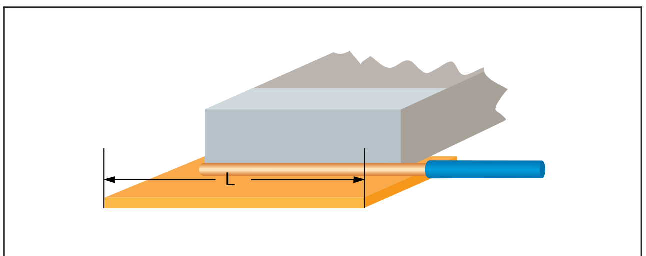

Figure 11-39

Target - Class 1,2,3

- Position lead parallel to longest dimension of the pad.
- Solder fillet equal to land width (L).

Acceptable - Class 1,2,3

- Minimum length of the solder connection is 50% of land width (L).

Defect - Class 1,2,3

- Solder connection length is less than 50% of land width (L).

11.2.5.2 Jumper Wires - SMT - Gull Wing

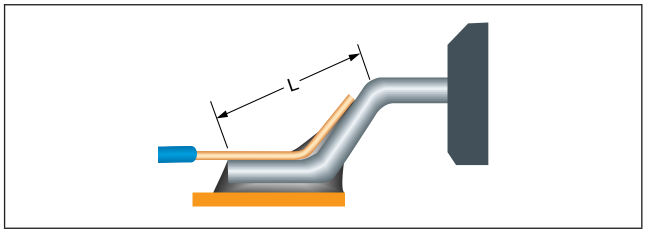

Figure 11-40

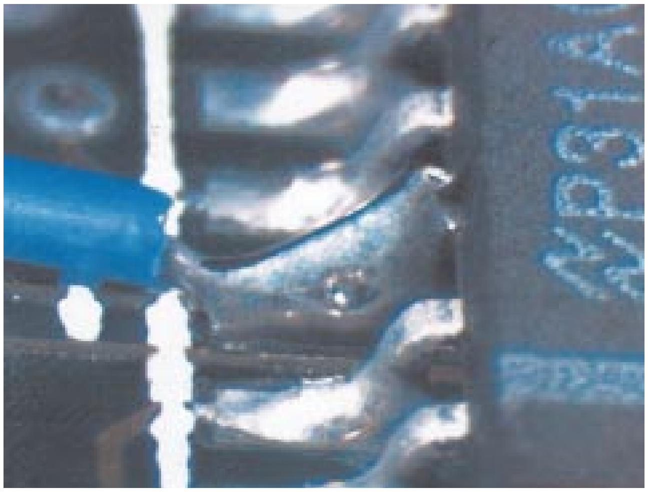

Figure 11-41

Figure 11-42

Acceptable - Class 1,2,3

- Minimum length of the solder connection is 75% of the length (L) (from toe to knee of lead).
- The wire end does not extend past the top of the component body.

Note: Jumper wires attached to components with leads such as toe-down/TSOP (thin, small outline packages) configurations may require unique criteria.

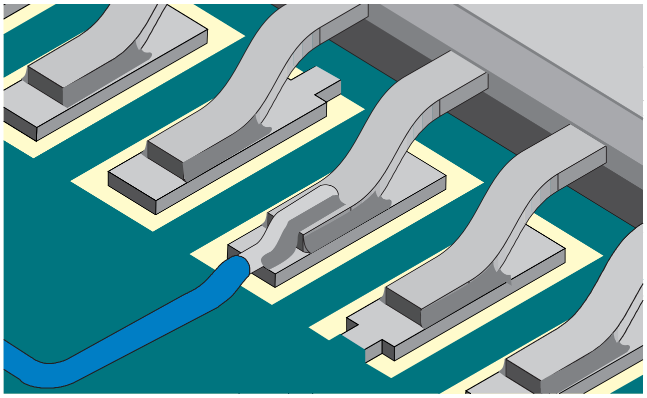

Figure 11-43

Defect - Class 1,2,3

- Fractured solder connection.
- Solder connection less than 75% of (L).

11.2.5.3 Jumper Wires - SMT - J Lead

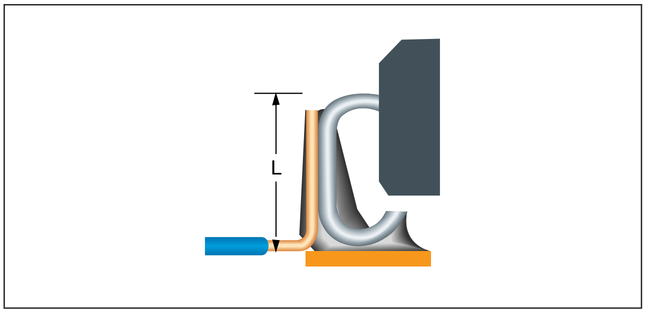

Figure 11-44

Target - Class 1,2,3

- Solder connection equal to (L).

Acceptable - Class 1,2,3

- Minimum length of the solder connection is 75% of (L) (height of the J lead).
- The wire end does not extend past the top of the component body.

Defect - Class 1,2,3

- Solder connection is less than 75% of (L).
- The wire end extends past the top of the component body.

11.2.5.4 Jumper Wires - SMT - Vacant Land/Pad

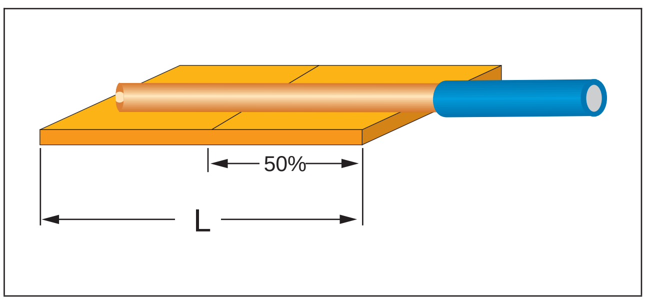

Figure 11-45

Target - Class 1,2,3

- Position lead parallel to longest dimension of the pad.
- Lead length and solder fillet equal to (L).

Acceptable - Class 1,2,3

- Minimum length of the solder connection is 50% of (L).

Defect - Class 1,2,3

- Solder connection length is less than 50% of (L).

Surface Mount Assemblies Acceptance Requirements

This section covers acceptability requirements for the fabrication of surface mount assemblies.

Criteria are given, not only for the mounting or placement of components, but also for soldering acceptability.

In this section, the criteria are grouped in five main subsections. The first three relate directly to the assembly process, starting with staking or bonding adhesives, leading into component placement and alignment, and finally the requirements for the various configurations of solder connections as may be required. The last two deal with acceptance criteria for varying degrees and types of soldering defects and component damage.

The dimension (G), solder thickness, is not an inspectable condition. Dimension (G) is the solder fillet from the top of the pad to the bottom of the termination.

Where the criteria lists a requirement for cleaning, it is applicable only when cleaning of the assembly is required.

Surface Mount Assemblies Acceptance Requirements (cont.)

The following topics are addressed in this section:

12.1 Staking Adhesive

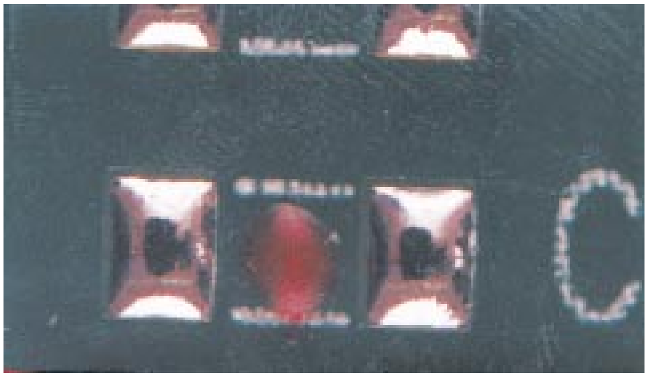

Figure 12-1

Target - Class 1,2,3

- No adhesive present on soldered surfaces of the connection area.
- Adhesive is centered between the lands.

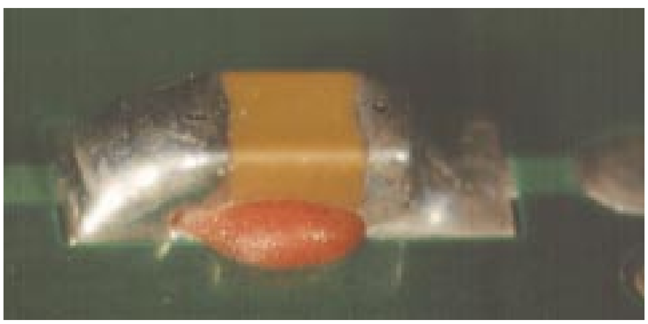

Figure 12-2

Acceptable - Class 1
Process Indicator - Class 2

- Adhesive material extending from under the component is visible in the termination area, but end joint width meets minimum requirements.

Defect - Class 3

- Adhesive materials extending from under the component are visible in the termination area.

12.1 Staking Adhesive (cont.)

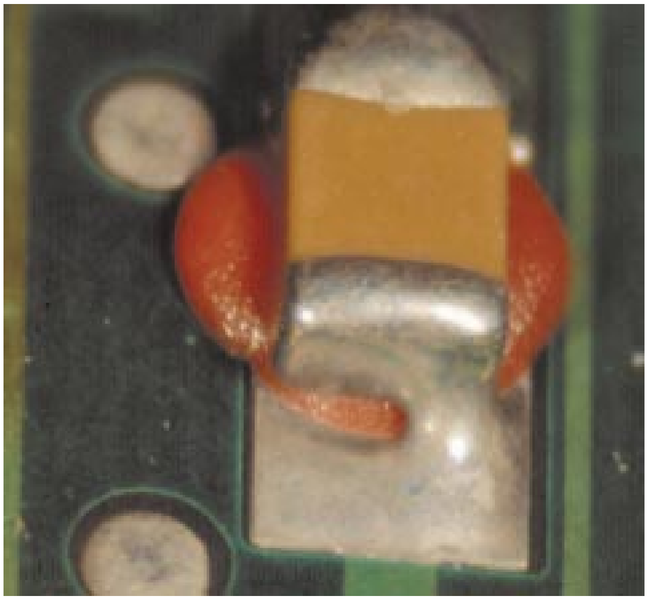

Figure 12-3

Defect - Class 1,2

- Adhesive is present in the solder connection area that reduces solder contact to less than 50% of the component termination width.

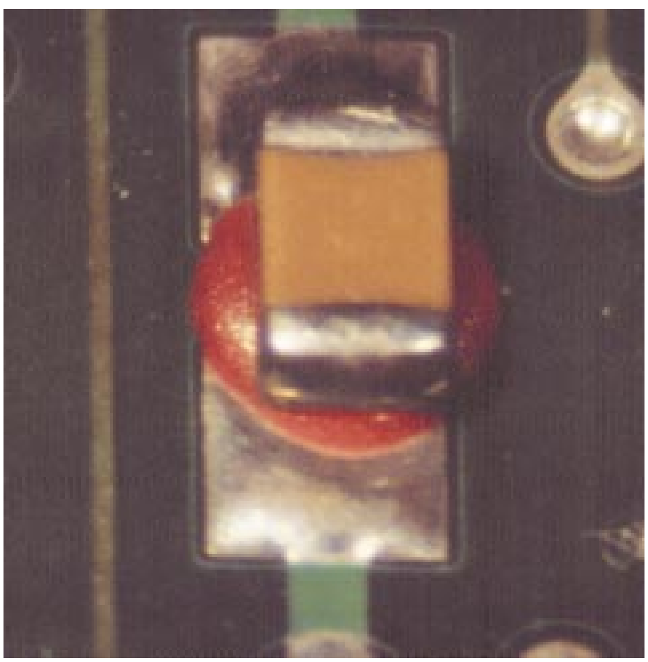

Figure 12-4

Defect - Class 1,2,3

- Lands and termination are contaminated with adhesive, with no solder fillet.

12.2 Solder Joints

12.2.1 Chip Components – Bottom Only Terminations

Discrete chip components, leadless chip carriers, and other devices that have metallizing terminations on the bottom side only must meet the dimensional and solder fillet requirements listed below for each product classification. The widths of the component and land are (W) and (P), respectively, and the termination overhang describes the condition where the smaller extends beyond the larger termination (i.e., W or P).

Table 12-1 Chip Component - Bottom Only Termination Features

Feature	Dim.
Maximum side overhang	A
Maximum end overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum fillet height	E
Minimum fillet height	F
Solder thickness	G
Land width	P
Termination length	T
Component termination width	W

12.2.1.1 Chip Components – Bottom Only Terminations, Side Overhang (A)

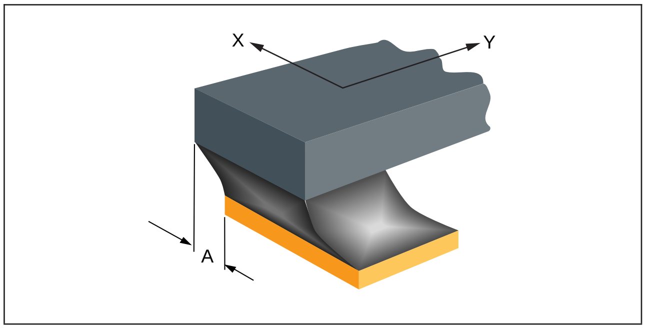

Figure 12-5

Note: Side Overhang (A) requirements are not specified for Class 1,2,3.

12.2.1.2 Chip Components – Bottom Only Terminations, End Overhang (B)

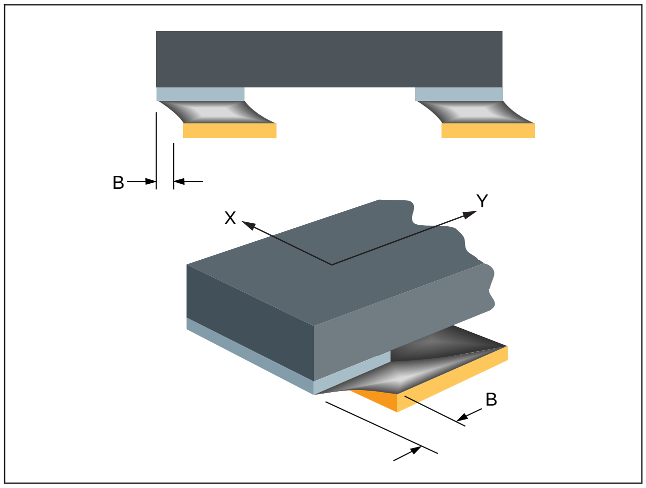

Figure 12-6

Defect - Class 1,2,3

• End overhang (B) in Y axis is not permitted.

12.2.1.3 Chip Components – Bottom Only Terminations, End Joint Width (C)

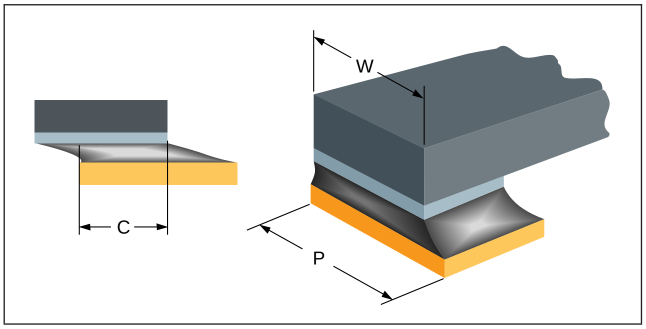

Figure 12-7

Target - Class 1,2,3

- End joint width (C) is equal to the width of the component termination (W) or width of land (P), whichever is less.

Acceptable - Class 1,2

- Minimum end joint width (C) is 50% width of component termination (W) or 50% width of land (P), whichever is less.

Acceptable - Class 3

- Minimum end joint width (C) is 75% width of component termination (W) or 75% width of land (P), whichever is less.

Defect - Class 1,2

- End joint width (C) is less than 50% width of component termination (W) or less than 50% width of land (P), whichever is less.

Defect - Class 3

- End joint width (C) is less than 75% width of component termination (W) or less than 75% width of land (P), whichever is less.

12.2.1.4 Chip Components – Bottom Only Terminations, Side Joint Length (D)

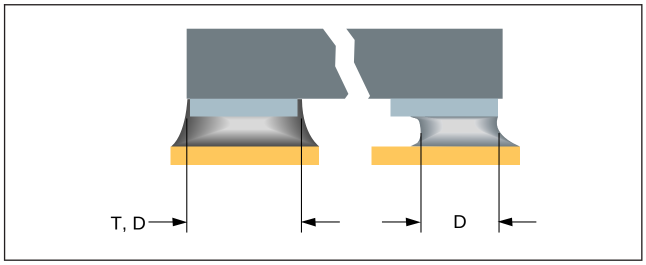

Figure 12-8

Target - Class 1,2,3

- Side joint length (D) equals component termination length (T).

Acceptable - Class 1,2,3

- Any side joint length (D) is acceptable if all other joint parameter requirements are met.

12.2.1.5 Chip Components – Bottom Only Terminations, Maximum Fillet Height (E)

Maximum filet height (E) requirements are not specified for Class 1,2,3.

12.2.1.6 Chip Components – Bottom Only Terminations, Minimum Fillet Height (F)

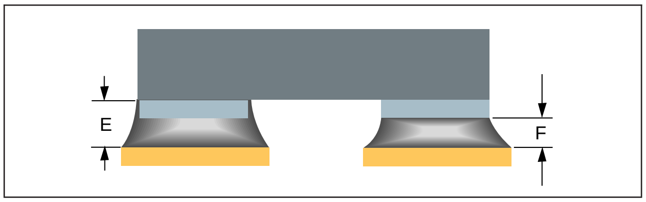

Figure 12-9

Minimum fillet height (F) requirements are not specified for Class 1,2,3. However, a properly wetted fillet is evident.

12.2.1.7 Chip Components – Bottom Only Terminations, Solder Thickness (G)

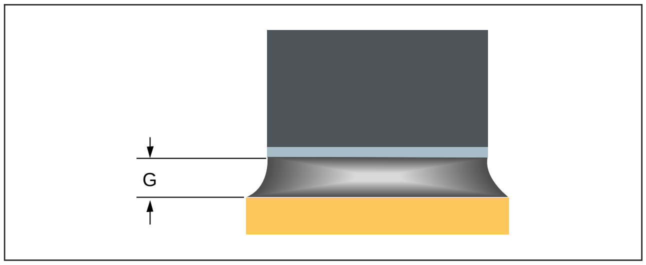

Figure 12-10

Acceptable - Class 1,2,3

- Properly wetted fillet evident.

12.2.2 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination

Solder joints to components having terminations of a square or rectangular configuration must meet the dimensional and solder fillet requirements listed below for each product classification. For 1 sided termination, the solderable side is the face of the component.

Table 12-2 Chip Component - 1, 3 or 5 Side Termination Features

Feature	Dim.
Maximum side overhang	A
Maximum end overhang	B
Minimum end joint width[1]	C
Minimum side joint length	D
Maximum fillet height	E
Minimum fillet height	F
Solder thickness	G
Termination height	H
Minimum end overlap	J
Land width	P
Termination length	T
Component termination width	W

Note 1. (C) is measured from the narrowest side of the solder fillet.

12.2.2.1 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Side Overhang (A)

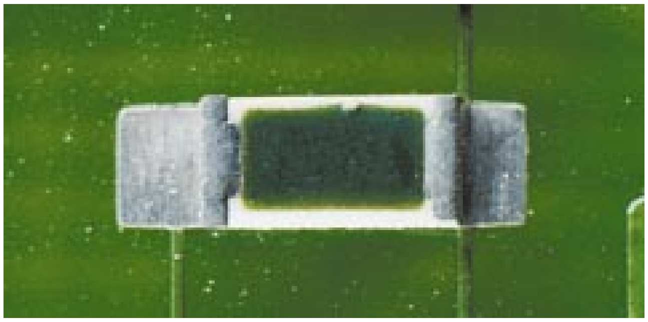

Figure 12-11

Target - Class 1,2,3

- No side overhang.

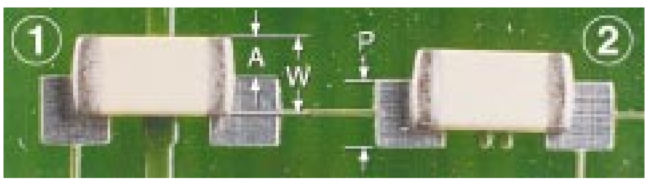

Figure 12-12
1. Class 2
2. Class 3

Acceptable - Class 1,2

- Side overhang (A) is less than or equal to 50% width of component termination area (W) or 50% width of land (P), whichever is less.

Acceptable - Class 3

- Side overhang (A) is less than or equal to 25% width of component termination area (W) or 25% width of land (P), whichever is less.

12.2.2.1 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Side Overhang (A) (cont.)

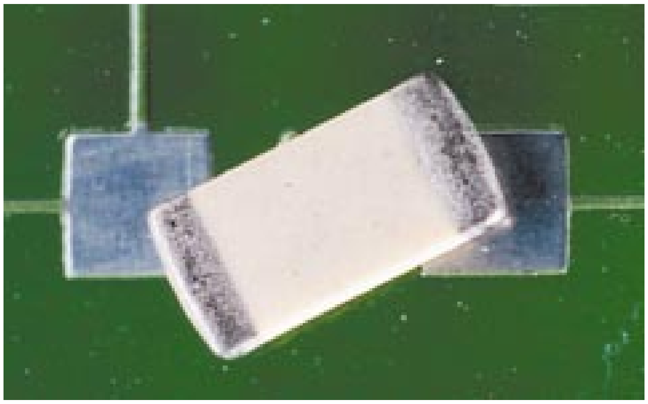

Figure 12-13

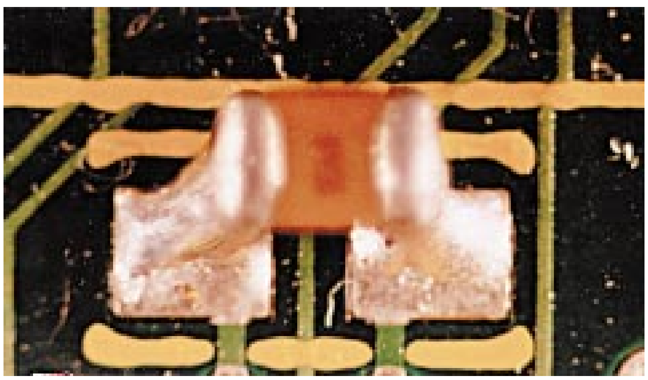

Figure 12-14

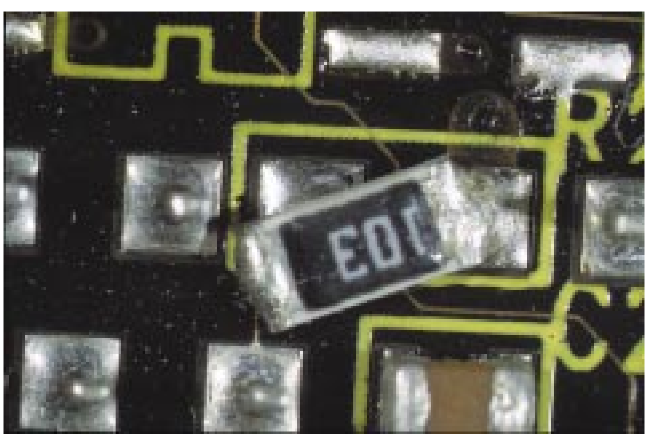

Figure 12-15

Defect - Class 1,2

- Side overhang (A) is greater than 50% component termination width (W) or 50% land width (P), whichever is less.

Defect - Class 3

- Side overhang (A) is greater than 25% component termination width (W) or 25% land width (P), whichever is less.

12.2.2.2 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, End Overhang (B)

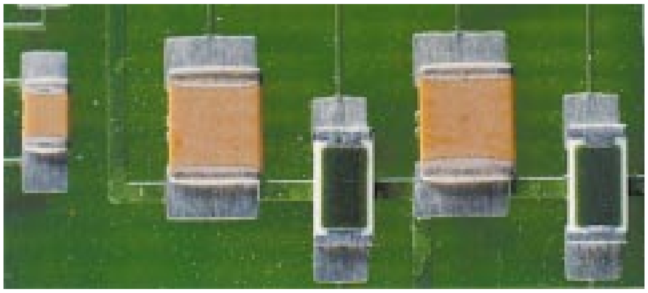

Figure 12-16

Target - Class 1,2,3

- No end overhang.

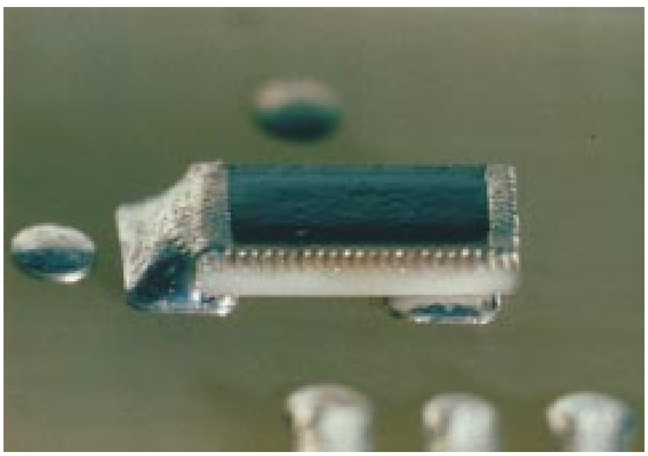

Figure 12-17

Defect - Class 1,2,3

- Termination overhangs land.

12.2.2.3 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, End Joint Width (C)

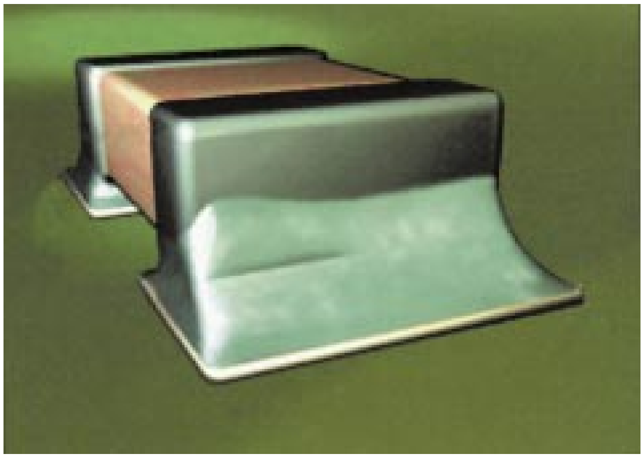

Figure 12-18

Target - Class 1,2,3

- End joint width is equal to component termination width or width of land, whichever is less.

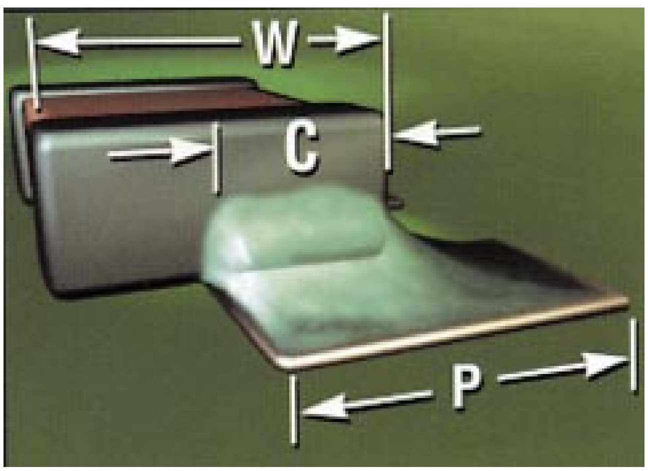

Figure 12-19

Acceptable - Class 1,2

- End joint width (C) is minimum 50% of component termination width (W) or 50% land width (P), whichever is less.

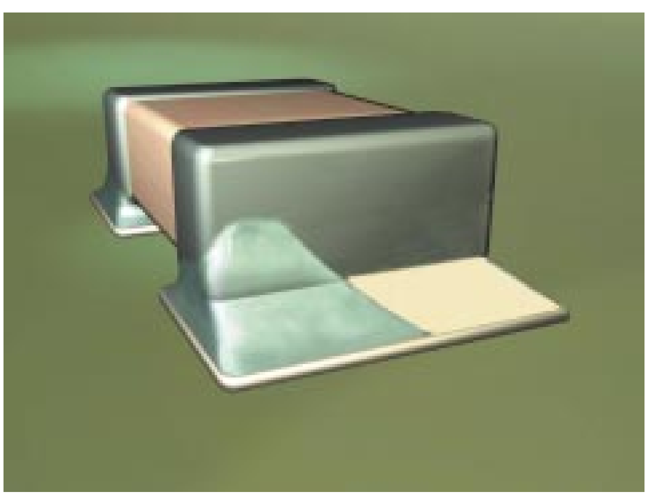

Figure 12-20

Defect - Class 1,2,3

- Less than minimum acceptable end joint width.

12.2.2.3 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, End Joint Width (C) (cont.)

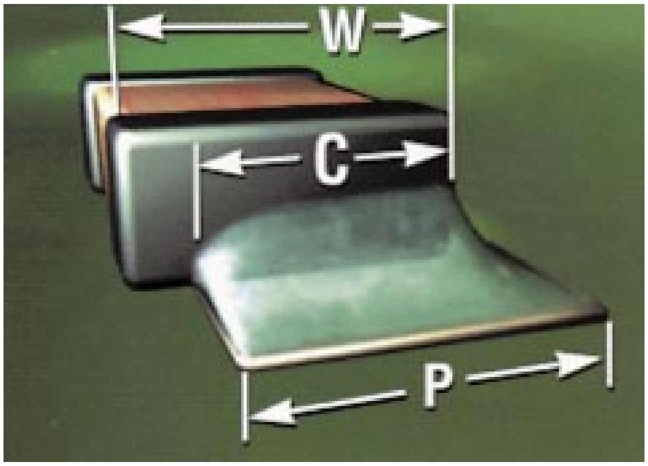

Figure 12-21

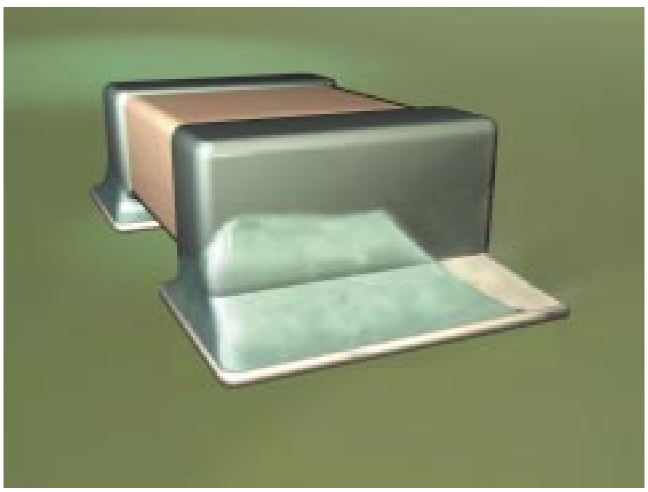

Figure 12-22

Acceptable - Class 3

- End joint width (C) is minimum 75% of component termination (W) or 75% land width (P), whichever is less.

12.2.2.4 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Side Joint Length (D)

Figure 12-23

Target - Class 1,2,3

- Side joint length equals length of component termination.

Acceptable - Class 1,2,3

- Side joint length is not required. However, a properly wetted fillet is evident.

12.2.2.5 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Maximum Fillet Height (E)

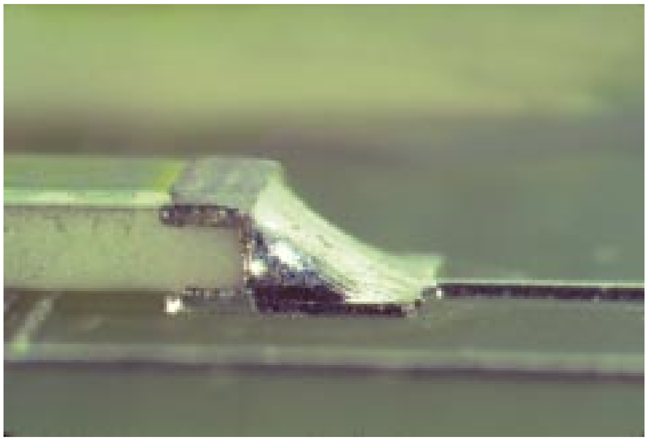

Figure 12-24

Target - Class 1,2,3

- Maximum fillet height is the solder thickness plus component termination height.

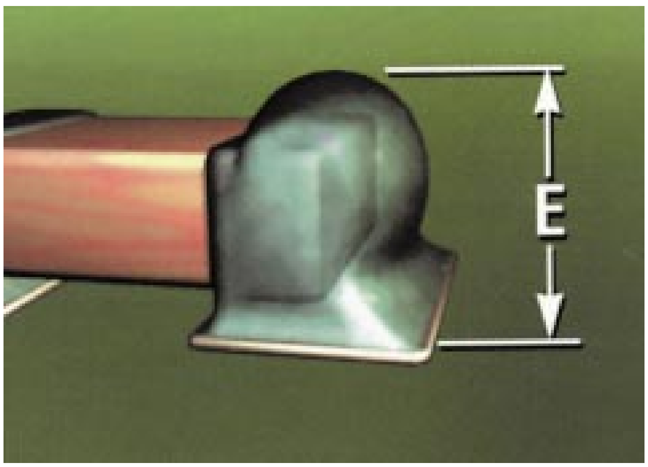

Figure 12-25

Acceptable - Class 1,2,3

- Maximum fillet height (E) may overhang the land or extend onto the top of the end cap metallization, but not extend further onto the component body.

Figure 12-26

Defect - Class 1,2,3

- Solder fillet extends onto the component body.

12.2.2.6 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Minimum Fillet Height (F)

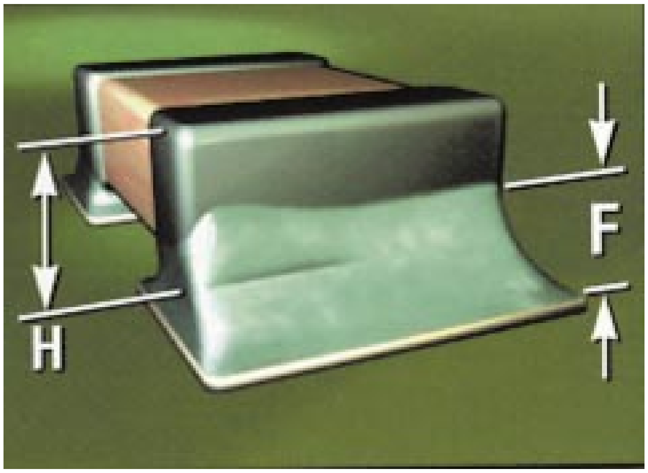

Figure 12-27

Acceptable - Class 1,2

• A properly wetted fillet is evident.

Acceptable - Class 3

• Minimum fillet height (F) is solder thickness (G) plus 25% termination height (H), or 0.5 mm [0.02 in], whichever is less.

Defect - Class 1,2

• A properly wetted fillet is not evident.

Defect - Class 3

• Minimum fillet height (F) is less than solder thickness (G) plus 25% (H), or solder thickness (G) plus 0.5 mm [0.02 in], whichever is less.

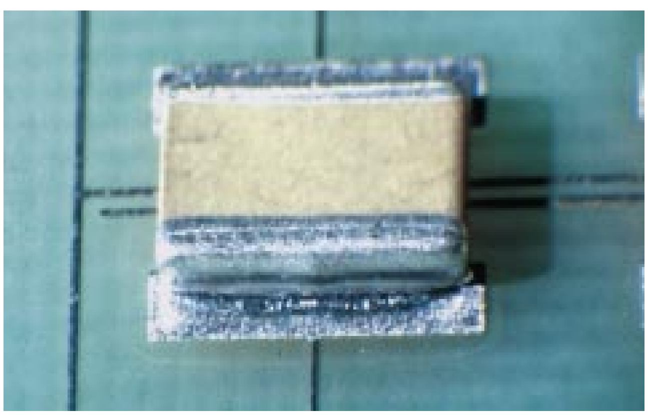

Figure 12-28

Defect - Class 1,2,3

• Insufficient solder.

12.2.2.7 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, Solder Thickness (G)

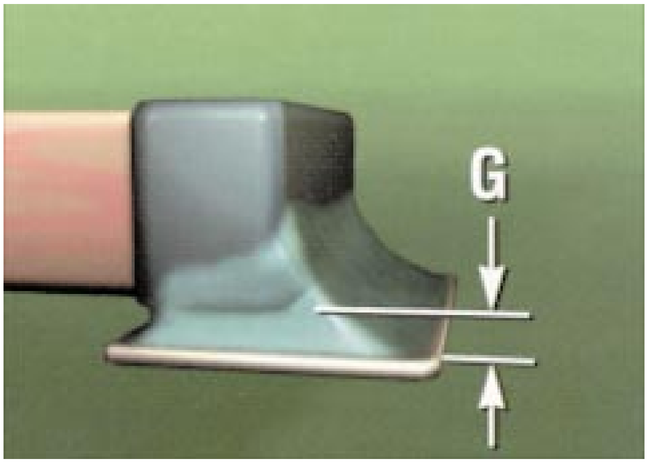

Figure 12-29

Acceptable - Class 1,2,3

• Properly wetted fillet evident.

12.2.2.8 Chip Components - Rectangular or Square End Components - 1, 3 or 5 Side Termination, End Overlap (J)

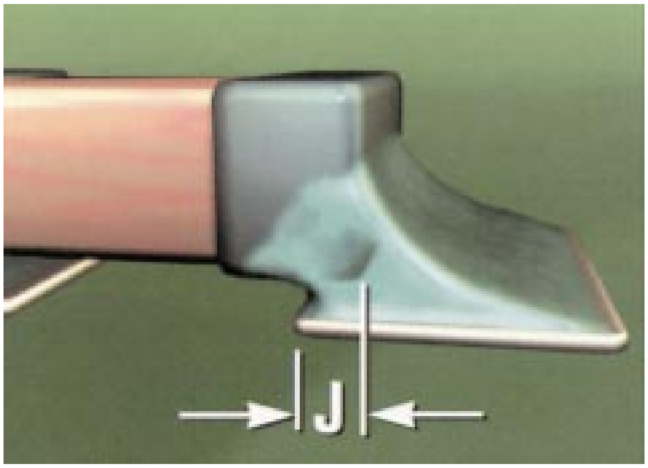

Figure 12-30

Acceptable - Class 1,2,3

• Evidence of overlap contact (J) between the component termination and the land is required.


Figure 12-31

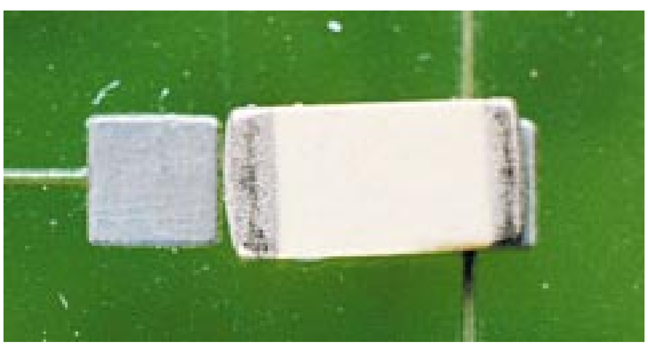
Figure 12-32

Defect - Class 1,2,3

• Insufficient end overlap.

12.2.3 Cylindrical End Cap Termination

Solder joints to components having cylindrical end cap terminations must meet the dimensional and solder fillet requirements for each product classification.

Table 12-3 Cylindrical End Cap Termination Features

Feature	Dim.
Maximum side overhang	A
Maximum end overhang	B
Minimum end joint width[1]	C
Minimum side joint length[2]	D
Maximum fillet height	E
Minimum fillet height (end and side)	F
Solder thickness	G
Minimum end overlap	J
Land width	P
Land length	S
Termination/plating length	T
Diameter of component	W

Note 1. (C) is measured from the narrowest side of the solder fillet.

Note 2. Does not apply to components with end only terminations.

12.2.3.1 Cylindrical End Cap Termination, Side Overhang (A)

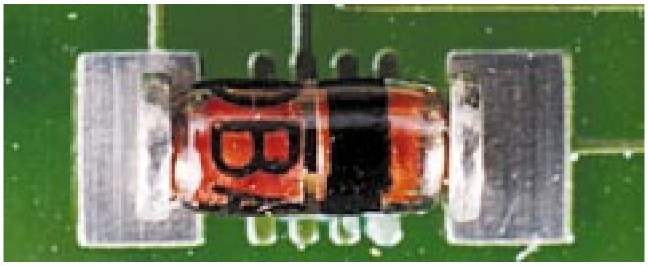

Figure 12-33

Target - Class 1,2,3

• No side overhang.

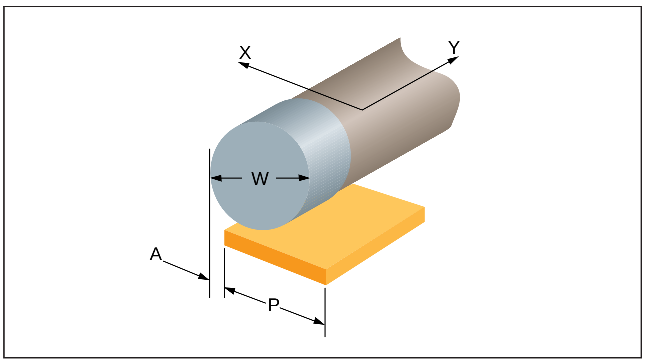

Figure 12-34

Acceptable - Class 1,2,3

• Side overhang (A) is less than 25% diameter of component width (W) or land width (P), whichever is less.

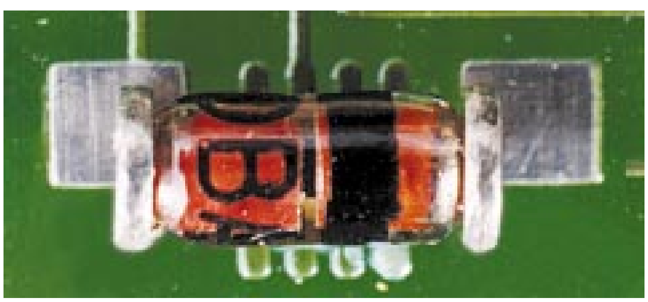

Figure 12-35

Defect - Class 1,2,3

• Side overhang (A) is greater than 25% of component diameter, (W), or land width (P), whichever is less.

12.2.3.2 Cylindrical End Cap Termination, End Overhang (B)

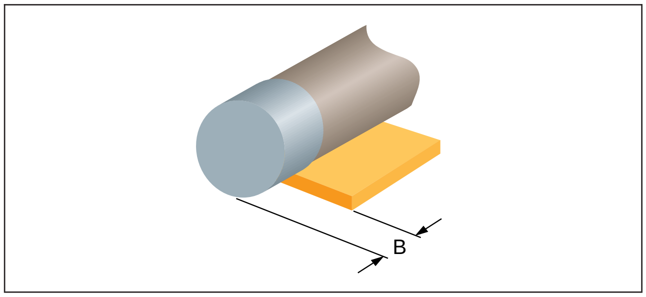

Figure 12-36

Target - Class 1,2,3

- No end overhang (B).

Defect - Class 1,2,3

- Any end overhang (B).

12.2.3.3 Cylindrical End Cap Termination, End Joint Width (C)

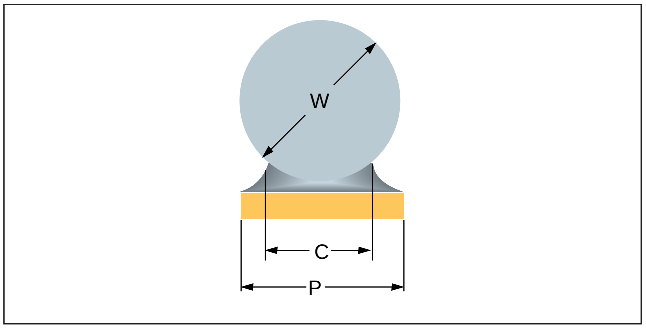

Figure 12-37

Figure 12-38

Target - Class 1,2,3

- End joint width is equal to or greater than the component diameter (W) or width of the land (P), whichever is less.

Acceptable - Class 1

- End solder joint exhibits a properly wetted fillet.

Acceptable - Class 2,3

- End joint width (C) is minimum 50% component diameter (W) or land width (P), whichever is less.

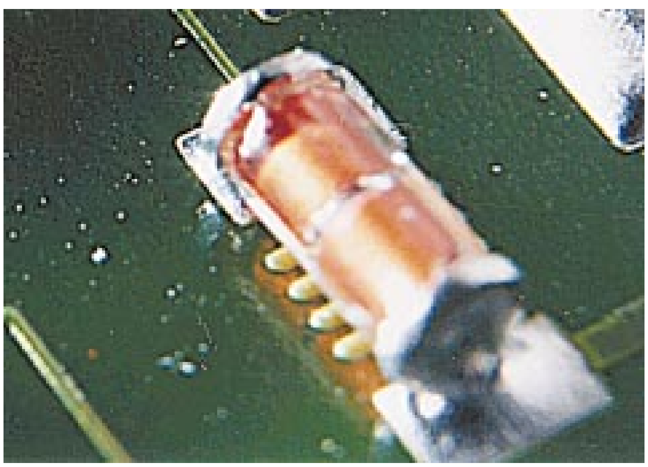

Figure 12-39

Defect - Class 1

- End solder joint does not exhibit a properly wetted fillet.

Defect - Class 2,3

- End joint width (C) is less than 50% component diameter (W), or land width (P), whichever is less.

12.2.3.4 Cylindrical End Cap Termination, Side Joint Length (D)

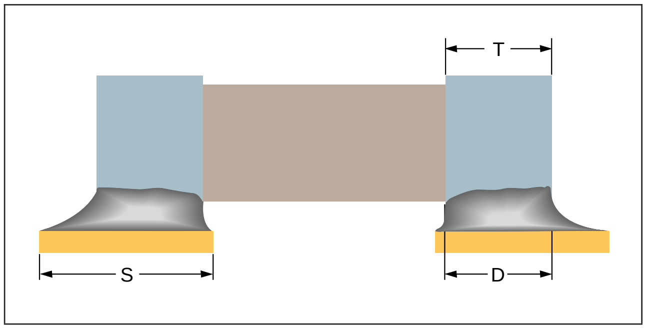

Figure 12-40

Figure 12-41

Target - Class 1,2,3

• Side joint length (D) is equal to the length of component termination (T) or land length (S), whichever is less.

Acceptable - Class 1

• Side joint length (D) exhibits a properly wetted fillet.

Acceptable - Class 2

• Side joint length (D) is minimum 50% length of component termination (T) or land length (S), whichever is less.

Acceptable - Class 3

• Side joint length (D) is minimum 75% length of component termination (T) or land length (S), whichever is less.

Defect - Class 1

• Side joint length (D) does not exhibit a properly wetted fillet.

Defect - Class 2

• Side joint length (D) is less than 50% length of component termination (T) or land length (S), whichever is less.

Defect - Class 3

• Side joint length (D) is less than 75% length of component termination (T) or land width, whichever is less.

12.2.3.5 Cylindrical End Cap Termination, Maximum Fillet Height (E)

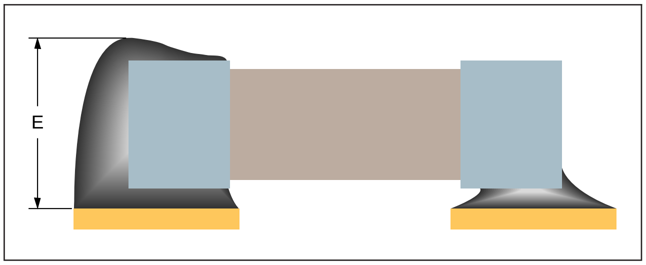

Figure 12-42

Acceptable - Class 1,2,3

- Maximum fillet height (E) may overhang the land or extend onto the top of the end cap metallization, but not extend further onto the component body.

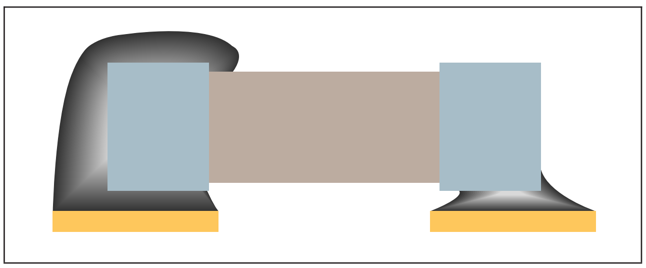

Figure 12-43

Defect - Class 1,2,3

- Solder fillet extends onto the component body.

12.2.3.6 Cylindrical End Cap Termination, Minimum Fillet Height (F)

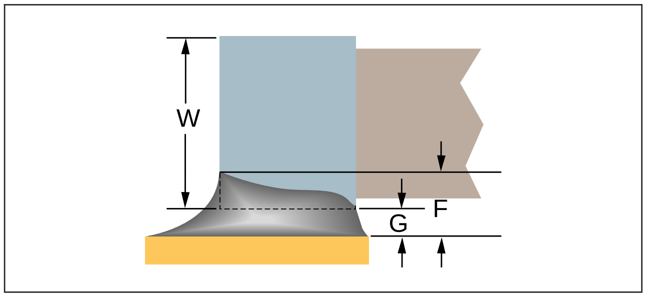

Figure 12-44

Acceptable - Class 1,2

- Minimum fillet height (F) exhibits proper wetting.

Acceptable - Class 3

- Minimum fillet height (F) is solder thickness (G) plus 25% diameter (W) of the component end cap or 1.0 mm [0.039 in], whichever is less.

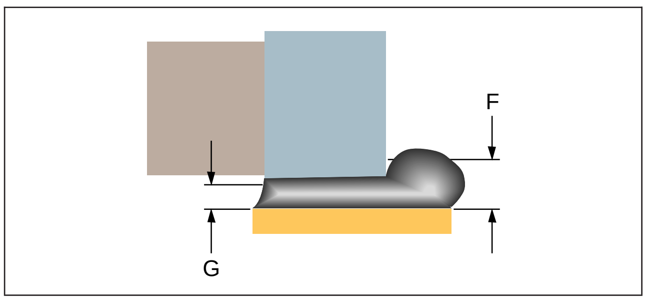

Figure 12-45

Defect - Class 1,2,3

- Minimum fillet height (F) does not exhibit proper wetting.

Defect - Class 3

- Minimum fillet height (F) is less than the solder thickness (G) plus 25% diameter (W) of the component end cap or 1.0 mm [0.039 in], whichever is less.

12.2.3.7 Cylindrical End Cap Termination, Solder Thickness (G)

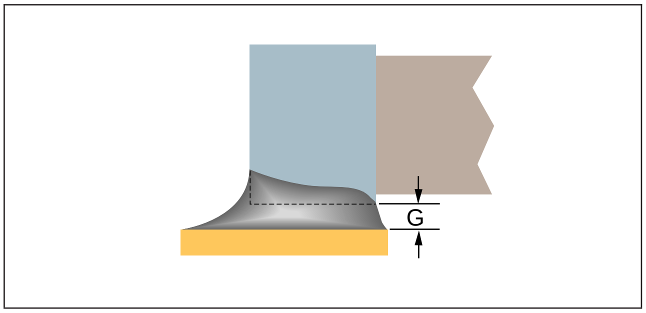

Figure 12-46

Acceptable - Class 1,2,3

• Properly wetted fillet evident.

12.2.3.8 Cylindrical End Cap Termination, End Overlap (J)

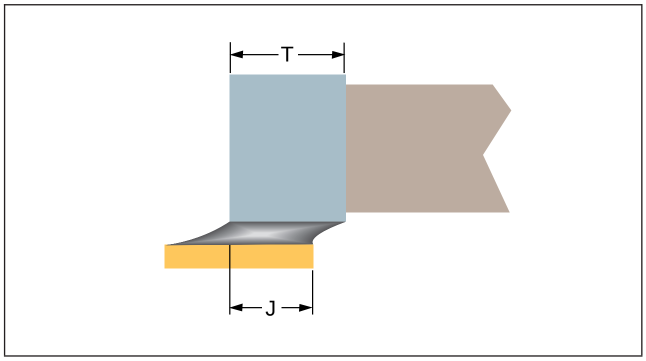

Figure 12-47

Acceptable - Class 1

- Properly wetted fillet is evident.

Acceptable - Class 2

- End overlap (J) between the component termination and the land is minimum 50% the length of component termination (T).

Acceptable - Class 3

- End overlap (J) between the component termination and the land is minimum of 75% the length of component termination (T).

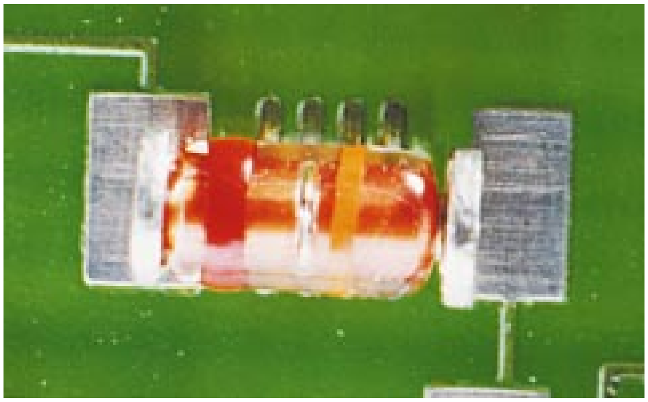

Figure 12-48

Defect - Class 1,2,3

- Component termination area and land do not overlap.

Defect - Class 2

- End overlap (J) is less than 50% of the length of component termination.

Defect - Class 3

- End overlap (J) is less than 75% of the length of component termination.

12.2.4 Leadless Chip Carriers with Castellated Terminations

Joints formed to castellated terminations of leadless chip components must meet the dimensional and solder fillet requirements listed below for each product classification.

Table 12-4 Leadless Chip Carrier Features

Feature	Dim.
Side overhang	A
End overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum fillet height	E
Minimum fillet height	F
Solder thickness	G
Castellation height	H
Land length external to package	S
Castellation width	W

12.2.4.1 Leadless Chip Carriers with Castellated Terminations, Side Overhang (A)

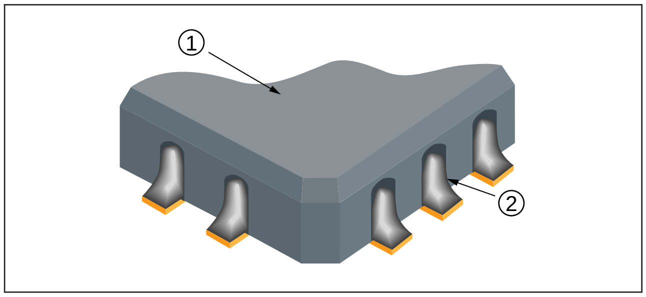

Figure 12-49

1. Leadless chip carrier
2. Castellations (Terminations)

Target - Class 1,2,3

- No side overhang.

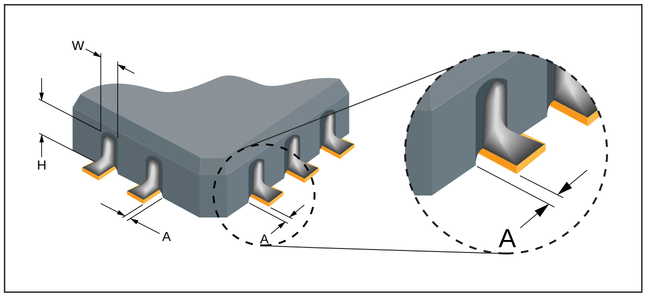

Figure 12-50

Acceptable - Class 1,2

- Maximum side overhang (A) is 50% castellation width (W).

Acceptable - Class 3

- Maximum side overhang (A) is 25% castellation width (W).

Defect - Class 1,2

- Side overhang (A) exceeds 50% castellation width (W).

Defect - Class 3

- Side overhang (A) exceeds 25% castellation width (W).

12.2.4.2 Leadless Chip Carriers with Castellated Terminations, End Overhang (B)

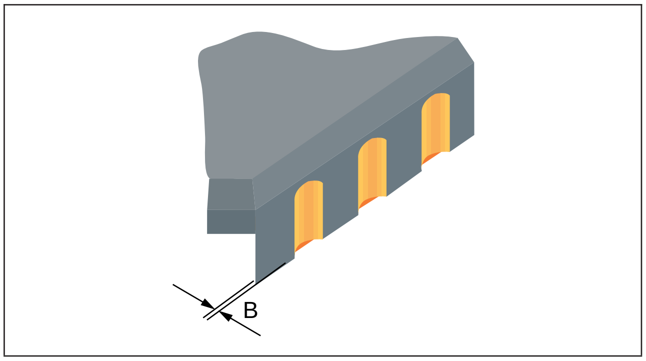

Figure 12-51

Defect - Class 1,2,3

- Any end overhang (B).

12.2.4.3 Leadless Chip Carriers with Castellated Terminations, Minimum End Joint Width (C)

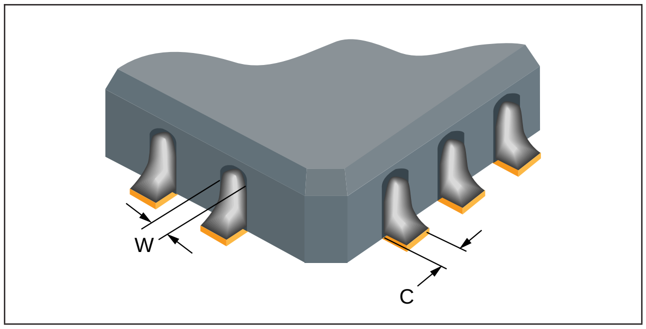

Figure 12-52

Target - Class 1,2,3

• End joint width (C) is equal to castellation width (W).

Acceptable - Class 1,2

• Minimum end joint width (C) is 50% castellation width (W).

Acceptable - Class 3

• Minimum end joint width (C) is 75% castellation width (W).

Defect - Class 1,2

• End joint width (C) is less than 50% castellation width (W).

Defect - Class 3

• End joint width (C) is less than 75% castellation width (W).

12.2.4.4 Leadless Chip Carriers with Castellated Terminations, Minimum Side Joint Length (D)

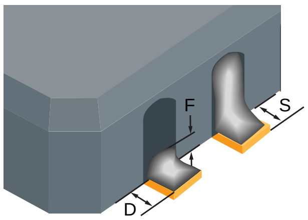

Figure 12-53

Acceptable - Class 1

- A properly wetted fillet is evident.

Acceptable - Class 2,3

- Minimum side joint length (D) is 50% minimum fillet height (F) or land length external to package (S), whichever is less.

Defect - Class 1

- A properly wetted fillet joint is not evident.

Defect - Class 2,3

- Minimum side joint length (D) is less than 50% minimum fillet height (F) or land length external to package (S), whichever is less.

12.2.4.5 Leadless Chip Carriers with Castellated Terminations, Maximum Fillet Height (E)

Maximum fillet height (E) requirements are not specified for Class 1,2,3.

12.2.4.6 Leadless Chip Carriers with Castellated Terminations, Minimum Fillet Height (F)

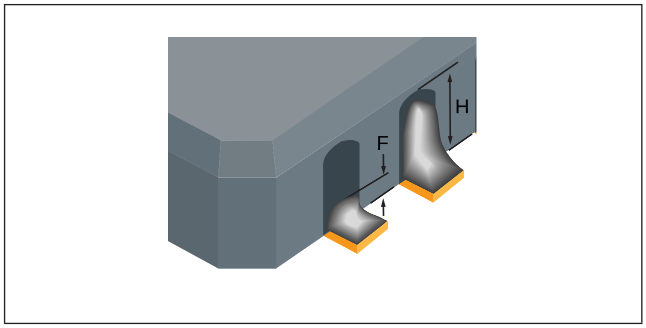

Figure 12-54

Acceptable - Class 1

- A properly wetted fillet is evident.

Acceptable - Class 2,3

- Minimum fillet height (F) is the solder thickness (G) plus 25% castellation height (H).

Figure 12-55

Defect - Class 1

- A properly wetted fillet is not evident.

Defect - Class 2,3

- Minimum fillet height (F) is less than solder thickness (G) plus 25% castellation height (H).

12.2.4.7 Leadless Chip Carriers with Castellated Terminations, Solder Thickness (G)

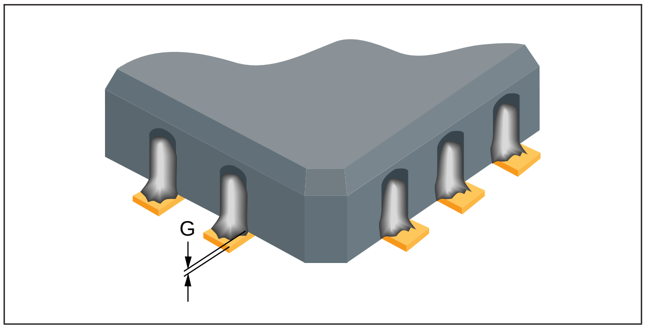

Figure 12-56

Acceptable - Class 1,2,3

• Properly wetted fillet evident.

12.2.5 Flat Ribbon, L, and Gull Wing Leads

Table 12-5 Flat Ribbon/Gull Wing Lead Features

Feature	Dim.
Maximum side overhang	A
Maximum toe overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum heel fillet height	E
Minimum heel fillet height	F
Solder thickness	G
Lead thickness	T
Lead width	W

12.2.5.1 Flat Ribbon, L, and Gull Wing Leads, Side Overhang (A)

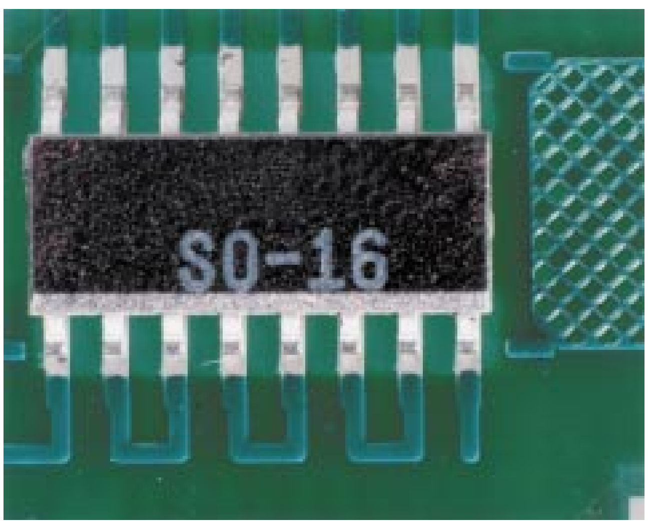

Figure 12-57

Target - Class 1,2,3

• No side overhang.

12.2.5.1 Flat Ribbon, L, and Gull Wing Leads, Side Overhang (A) (cont.)

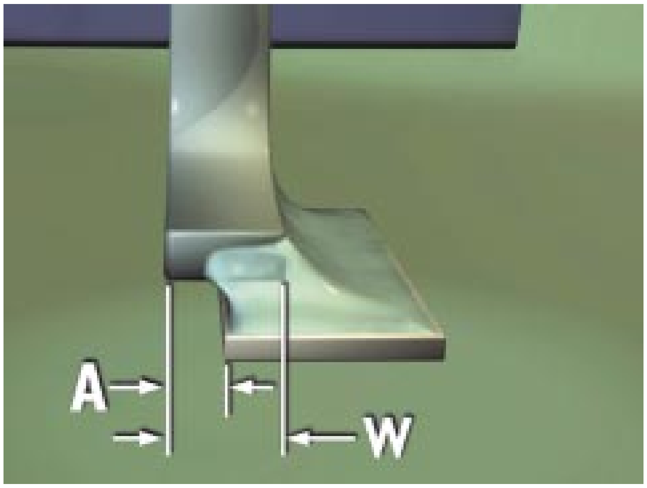

Figure 12-58

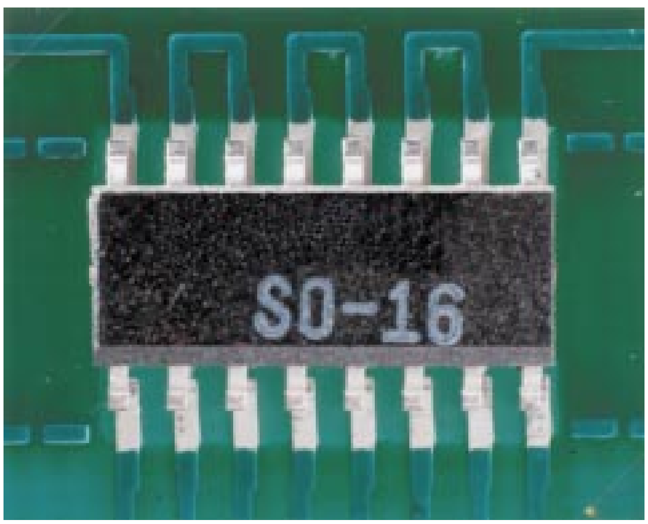

Figure 12-59

Acceptable - Class 1,2

- Maximum overhang (A) is not greater than 50% lead width (W) or 0.5 mm [0.02 in], whichever is less.

12.2.5.1 Flat Ribbon, L, and Gull Wing Leads, Side Overhang (A) (cont.)

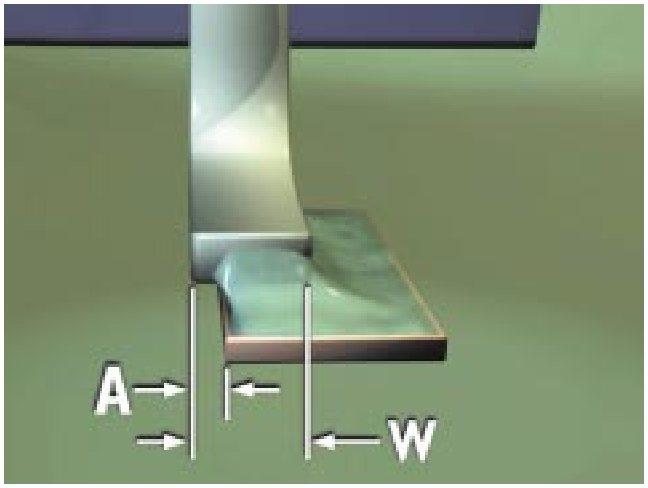

Figure 12-60

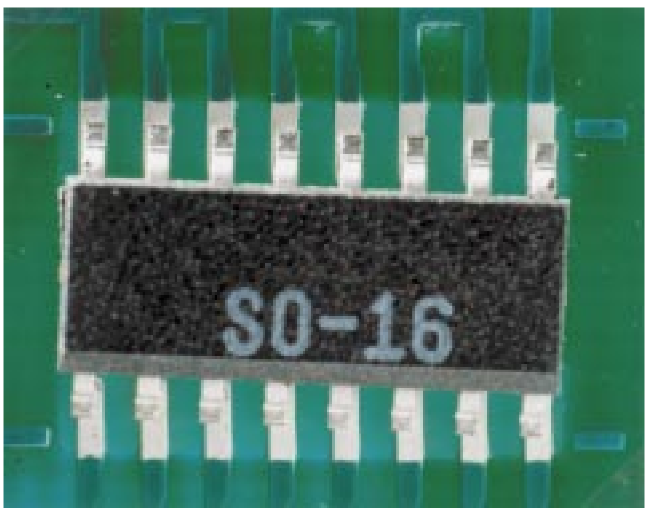

Figure 12-61

Acceptable - Class 3

- Maximum overhang (A) is not greater than 25% lead width (W) or 0.5 mm [0.02 in], whichever is less.

12.2.5.1 Flat Ribbon, L, and Gull Wing Leads, Side Overhang (A) (cont.)

Figure 12-62

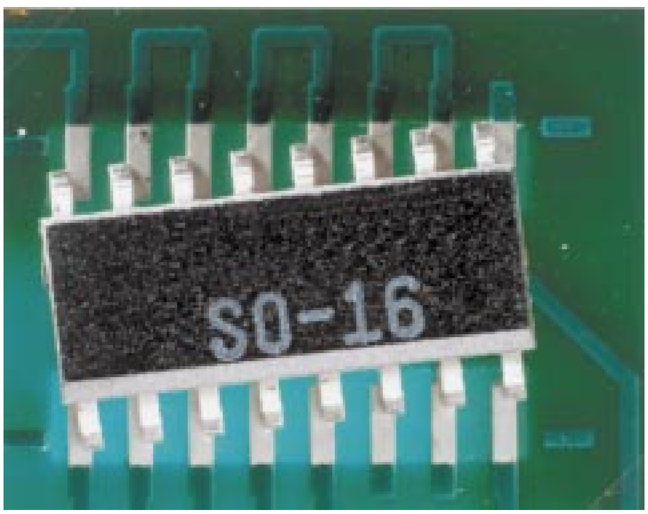

Figure 12-63

Defect - Class 1,2

- Side overhang (A) is greater than 50% lead width (W) or 0.5 mm [0.02 in], whichever is less.

Defect - Class 3

- Side overhang (A) is greater than 25% lead width (W) or 0.5 mm [0.02 in], whichever is less.

12.2.5.2 Flat Ribbon, L, and Gull Wing Leads, Toe Overhang (B)

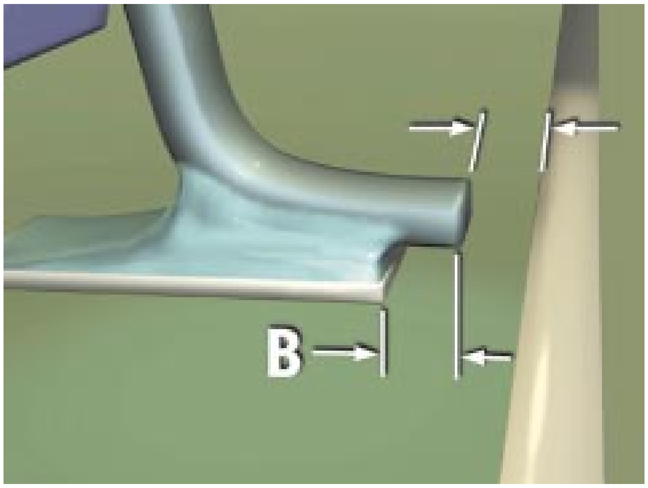

Figure 12-64

Acceptable - Class 1,2,3

- Toe overhang does not violate minimum electrical clearance or minimum heel fillet requirements.

Defect - Class 1,2,3

- Toe overhang violates minimum electrical clearance.

12.2.5.3 Flat Ribbon, L, and Gull Wing Leads, Minimum End joint Width (C)

Figure 12-65

Target - Class 1,2,3

• End joint width is equal to or greater than lead width.

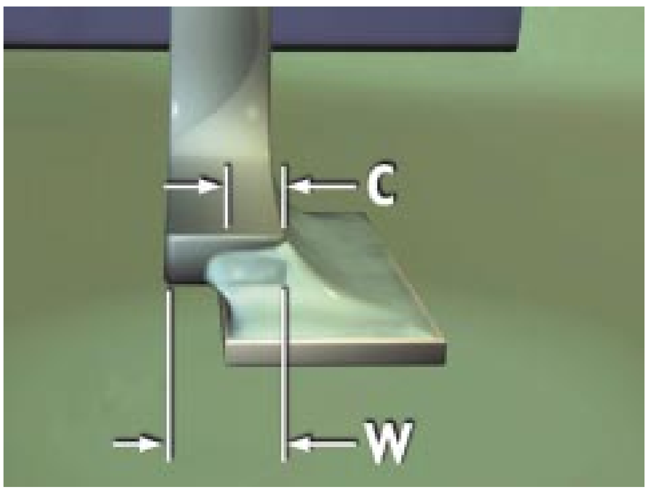

Figure 12-66

Acceptable - Class 1,2

• Minimum end joint width (C) is 50% lead width (W).

12.2.5.3 Flat Ribbon, L, and Gull Wing Leads, Minimum End joint Width (C) (cont.)

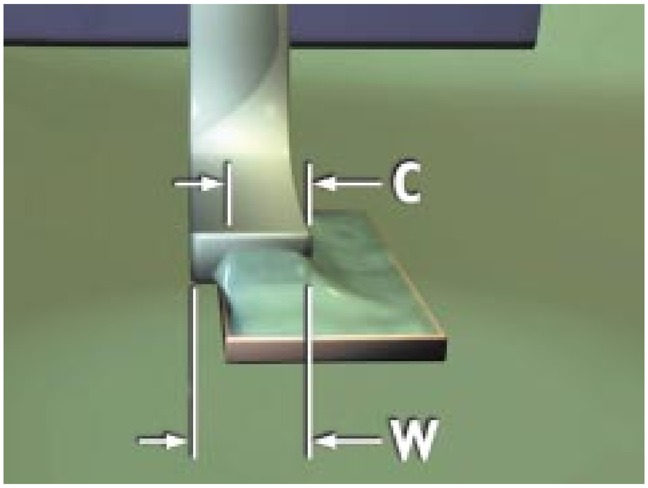

Figure 12-67

Acceptable - Class 3

- Minimum end joint width (C) is 75% lead width (W).

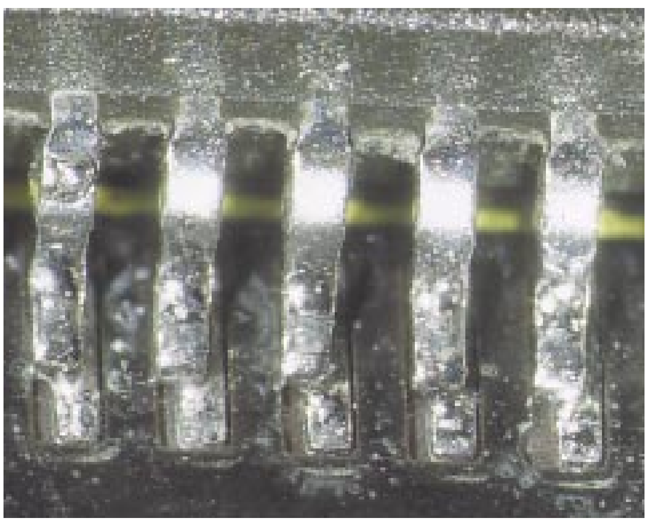

Figure 12-68

Defect - Class 1,2

- Minimum end joint width (C) is less than 50% lead width (W).

Defect - Class 3

- Minimum end joint width (C) is less than 75% lead width (W).

12.2.5.4 Flat Ribbon, L, and Gull Wing Leads, Minimum Side Joint Length (D)

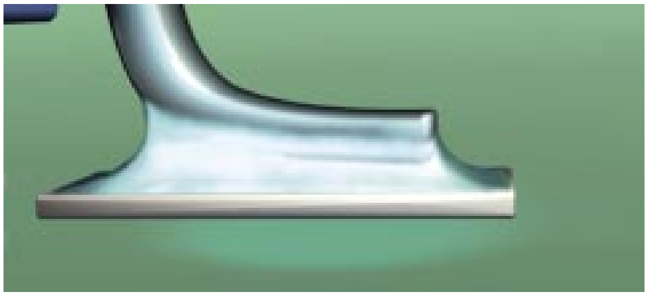

Figure 12-69

Figure 12-70

Target - Class 1,2,3

- Evidence of properly wetted fillet along full length of lead.

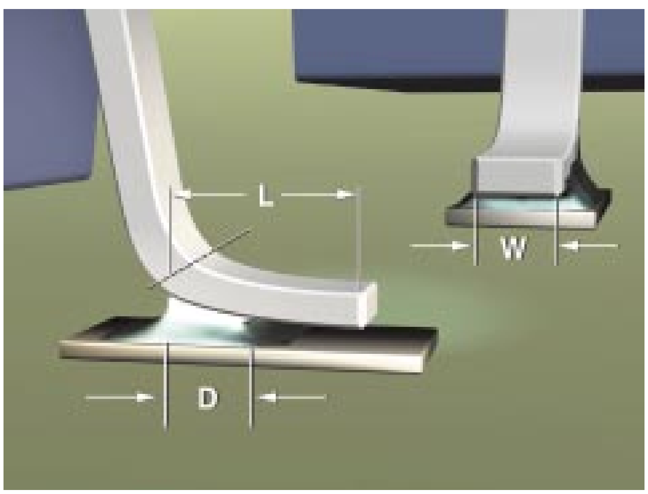

Figure 12-71

Acceptable - Class 1

- Minimum side joint length (D) is equal to lead width (W) or 0.5 mm [0.02 in], whichever is less.

Acceptable - Class 2,3

- Minimum side joint length (D) is equal to lead width (W).
- When lead length (L) (as measured from toe to mid-point of heel bend radius) is less than (W), minimum side joint length (D) is at least 75% lead length (L).

Defect - Class 1

- Minimum side joint length (D) is less than the lead width (W) or 0.5 mm [0.02 in], whichever is less.

Defect - Class 2,3

- Side joint length (D) is less than lead width (W) or 75% of lead length (L), whichever is less.

12.2.5.5 Flat Ribbon, L, and Gull Wing Leads, Maximum Heel Fillet Height (E)

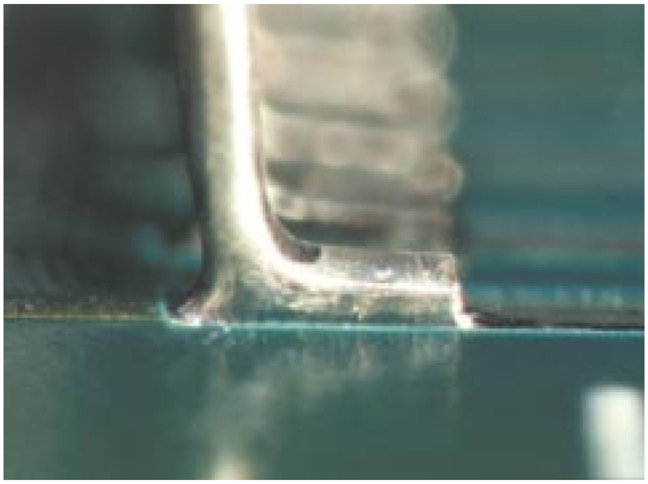

Figure 12-72

Target - Class 1,2,3

- Heel fillet extends above lead thickness but does not fill upper lead bend.

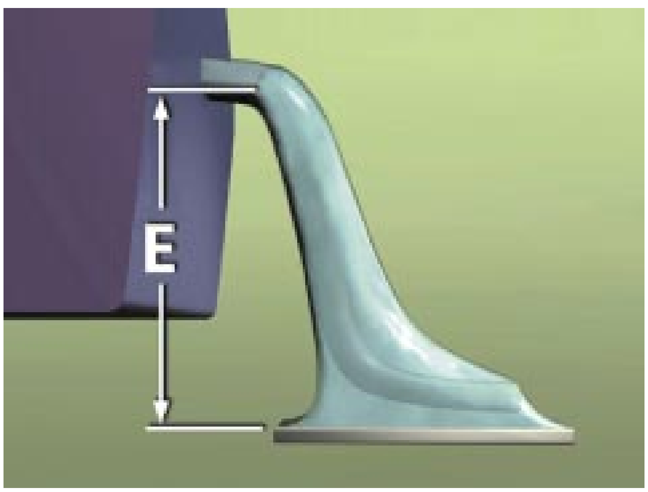

Figure 12-73

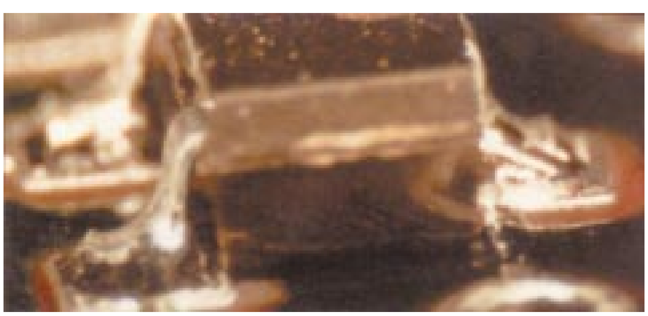

Figure 12-74

Acceptable - Class 1,2,3

- Devices with high lead configuration (leads exiting from the upper half of the body, i.e., QFPs, SOLs, etc.), solder may extend to, but must not touch the package body or end seal.

12.2.5.5 Flat Ribbon, L, and Gull Wing Leads, Maximum Heel Fillet Height (E) (cont.)

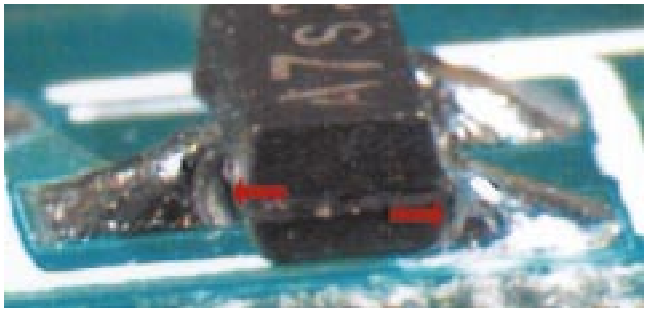

Figure 12-75

Acceptable - Class 1,2,3

- Devices with low lead configuration (leads exiting from or near the lower part of the package, i.e., SOICs, SOTs, etc.) may have solder extend to the package or under the body.

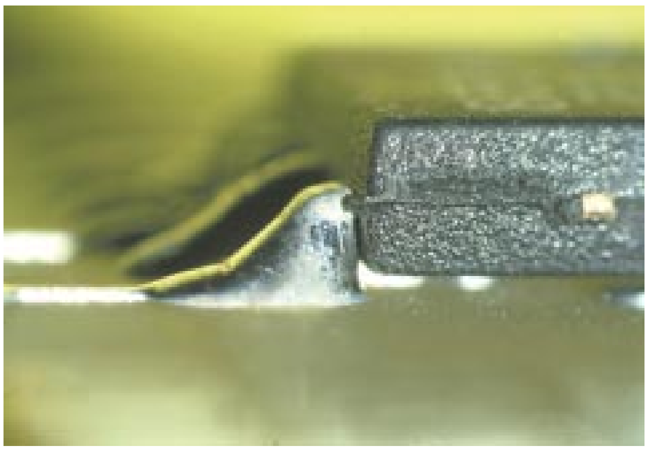

Figure 12-76

Defect - Class 2,3

- Solder touches the body or end seal of high-lead configuration components.

12.2.5.6 Flat Ribbon, L, and Gull Wing Leads, Minimum Heel Fillet Height (F)

Acceptable - Class 1,2,3

- In the case of a toe-down configuration (not shown), the minimum heel fillet height (F) extends at least to the mid-point of the outside lead bend.

Defect - Class 1,2,3

- In the case of a toe-down configuration, the minimum heel fillet height (F) does not extend at least to the mid-point of the outside lead bend.

12.2.5.6 Flat Ribbon, L, and Gull Wing Leads, Minimum Heel Fillet Height (F) (cont.)

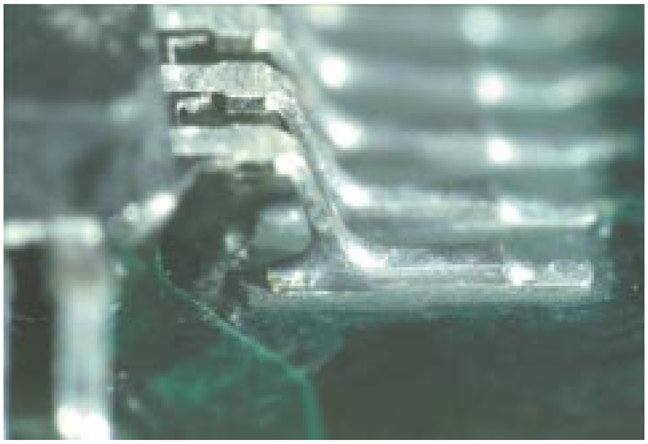

Figure 12-77

Acceptable - Class 1

• A properly wetted fillet is evident.

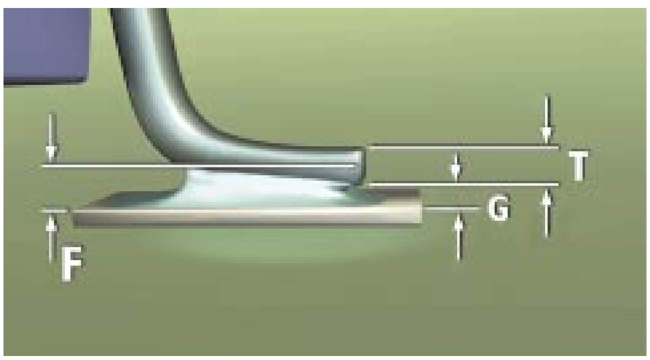

Figure 12-78

Acceptable - Class 2

• Minimum heel fillet height (F) is equal to solder thickness (G) plus 50% lead thickness (T) at connection side.

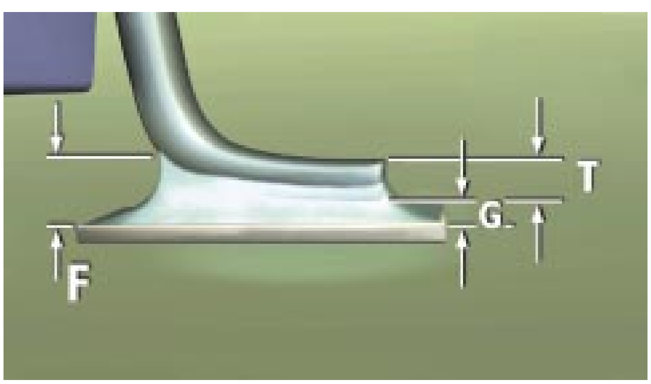

Figure 12-79

Acceptable - Class 3

• Minimum heel fillet height (F) is equal to solder thickness (G) plus lead thickness (T) at connection side.

12.2.5.6 Flat Ribbon, L, and Gull Wing Leads, Minimum Heel Fillet Height (F) (cont.)

Figure 12-80

Defect - Class 1

• A properly wetted fillet is not evident.

Defect - Class 2

• Minimum heel fillet height (F) is less than solder thickness (G) plus 50% lead thickness (T) at connection side.

Defect - Class 3

• Minimum heel fillet height (F) is less than solder thickness (G) plus lead thickness (T) at connection side.

12.2.5.7 Flat Ribbon, L, and Gull Wing Leads, Solder Thickness (G)

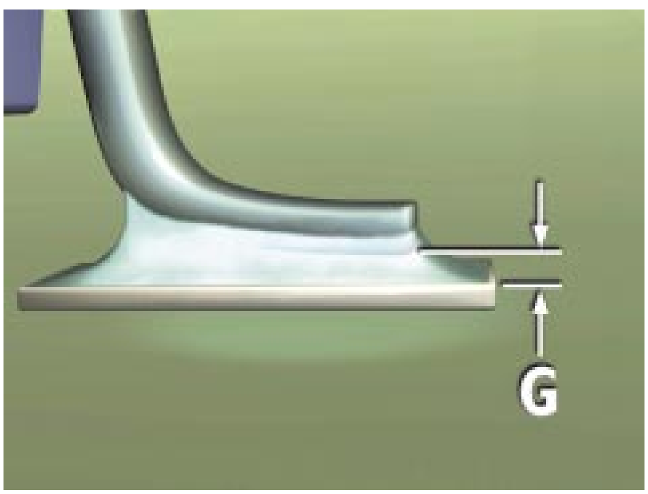

Figure 12-81

Acceptable - Class 1,2,3

• Properly wetted fillet evident.

12.2.6 Round or Flattened (Coined) Leads

Table 12-6 Round or Flattened Lead Features

Feature	Dim.
Maximum side overhang	A
Maximum toe overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum heel fillet height	E
Minimum heel fillet height	F
Solder thickness	G
Minimum side joint height	Q
Thickness of lead at joint side	T
Width of flattened lead/diameter of round lead	W

12.2.6.1 Round or Flattened (Coined) Leads, Side Overhang (A)

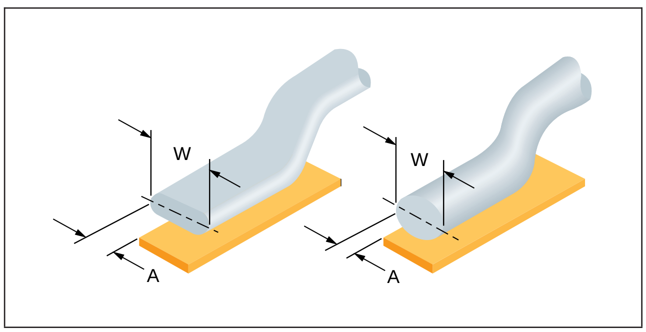

Figure 12-82

Target - Class 1,2,3

- No side overhang.

Acceptable - Class 1,2

- Side overhang (A) is not greater than 50% lead width/diameter (W).

Acceptable - Class 3

- Side overhang (A) is not greater than 25% lead width/diameter (W).

Defect - Class 1,2

- Side overhang (A) is greater than 50% lead width/diameter (W).

Defect - Class 3

- Side overhang (A) is greater than 25% lead width/diameter (W).

12.2.6.2 Round or Flattened (Coined) Leads, Toe Overhang (B)

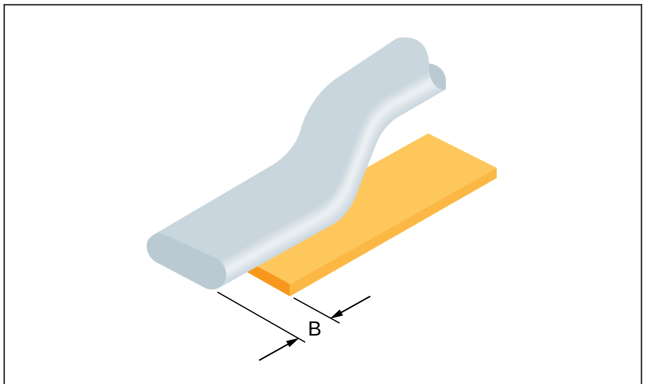

Figure 12-83

Acceptable - Class 1,2,3

- Toe overhang (B) is not specified.
- Does not violate minimum electrical clearance.

Defect - Class 1,2,3

- Toe overhang violates minimum electrical clearance.

12.2.6.3 Round or Flattened (Coined) Leads, Minimum End Joint Width (C)

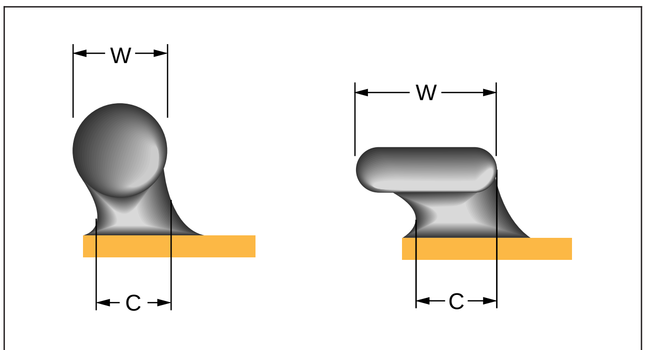

Figure 12-84

Target - Class 1,2,3

- End joint width (C) is equal to or greater than lead width/diameter (W).

Acceptable - Class 1,2

- Properly wetted fillet is evident.

Acceptable - Class 3

- End joint width (C) is minimum 75% lead width/diameter (W).

Defect - Class 1,2

- No evidence of properly wetted fillet.

Defect - Class 3

- Minimum end joint width (C) is less than 75% lead width/diameter (W).

12.2.6.4 Round or Flattened (Coined) Leads, Minimum Side Joint Length (D)

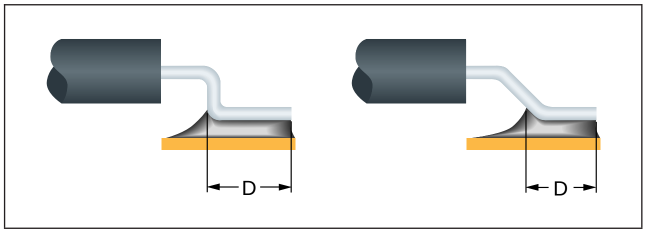

Figure 12-85

Acceptable - Class 1,2

• Side joint length (D) is equal to lead width/diameter (W).

Acceptable - Class 3

• Minimum side joint length (D) is equal to 150% lead width/ diameter (W).

Defect - Class 1,2

• Side joint length (D) is less than lead width/diameter (W).

Defect - Class 3

• Minimum side joint length (D) is less than 150% the lead width/diameter (W).

12.2.6.5 Round or Flattened (Coined) Leads, Maximum Heel Fillet Height (E)

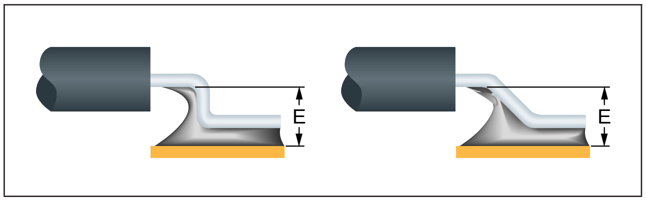

Figure 12-86

Acceptable - Class 1,2,3

- Solder does not touch the package body with high-lead configuration.

Note: Some lead configurations are, by design, more prone to encouraging solder climb, particularly with wave solder processes. Inspectors should consider the normal soldering characteristics when determining acceptance.

Defect - Class 1

- A properly wetted fillet is not evident.

Defect - Class 2,3

- Solder touches the package or end seal except for devices with low-lead configuration.

Defect - Class 1,2,3

- Solder is excessive so that the minimum electrical clearance is violated.

12.2.6.6 Round or Flattened (Coined) Leads, Minimum Heel Fillet Height (F)

Acceptable - Class 1,2,3

- In the case of a toe-down configuration (not shown), the minimum heel fillet height (F) extends at least to the mid-point of the outside lead bend.

Defect - Class 1,2,3

- In the case of a toe-down configuration, the minimum heel fillet height (F) does not extend at least to the mid-point of the outside lead bend.

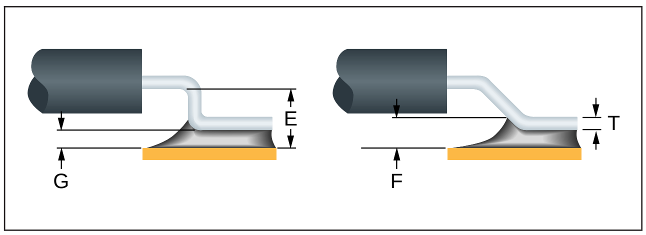

Figure 12-87

Acceptable - Class 1

- A properly wetted fillet is evident.

Acceptable - Class 2

- Minimum heel fillet height (F) is equal to solder thickness (G) plus 50% thickness of lead at joint side (T).

Acceptable - Class 3

- Minimum heel fillet height (F) is equal to solder thickness (G) plus thickness of lead at joint side (T).

Defect - Class 1

- A properly wetted fillet is not evident.

Defect - Class 2

- Minimum heel fillet height (F) is less than solder thickness (G) plus 50% thickness of lead at joint side (T).

Defect - Class 3

- Minimum heel fillet height (F) is less than solder thickness (G) plus thickness of lead at joint side (T).

12.2.6.7 Round or Flattened (Coined) Leads, Solder Thickness (G)

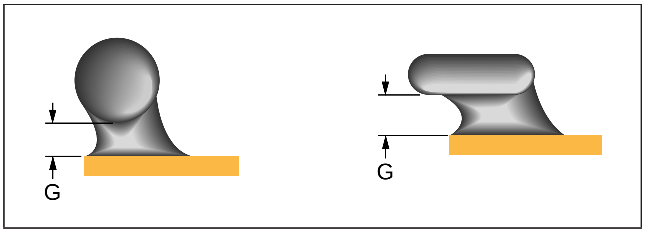

Figure 12-88

Acceptable - Class 1,2,3

- Properly wetted fillet evident.

12.2.6.8 Round or Flattened (Coined) Leads, Minimum Side Joint Height (Q)

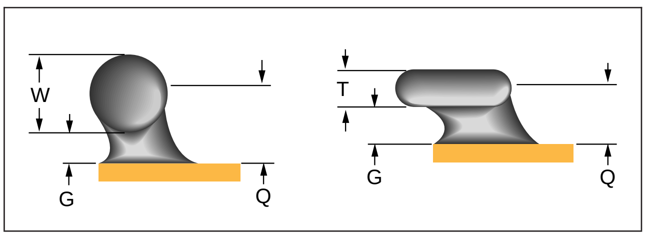

Figure 12-89

Acceptable - Class 1

- A properly wetted fillet is evident.

Acceptable - Class 2,3

- Minimum side joint height (Q) is equal to or greater than solder thickness (G) plus 50% diameter (W) of round lead or 50% thickness of lead at joint side (T) for coined lead.

Defect - Class 1

- A properly wetted fillet is not evident.

Defect - Class 2,3

- Minimum side joint height (Q) is less than solder thickness (G) plus 50% diameter (W) of round lead or 50% thickness of lead at joint side (T) for coined lead.

12.2.7 J Leads

Joints formed to leads having a J shape at the joint site must meet the dimensional and fillet requirements listed below for each product classification.

Table 12-7 J-Lead Features

Feature	Dim.
Maximum side overhang	A
Maximum toe overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum fillet height	E
Minimum heel fillet height	F
Solder thickness	G
Lead thickness	T
Lead width	W

12.2.7.1 J Leads, Side Overhang (A)

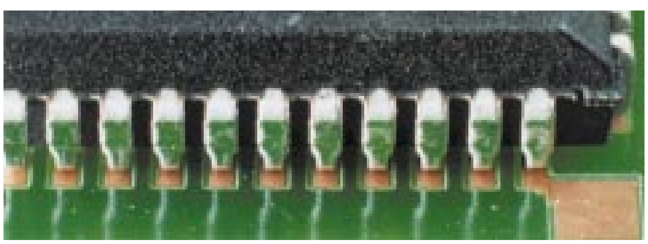

Figure 12-90

Target - Class 1,2,3

- No side overhang.

12.2.7.1 J Leads, Side Overhang (A) (cont.)

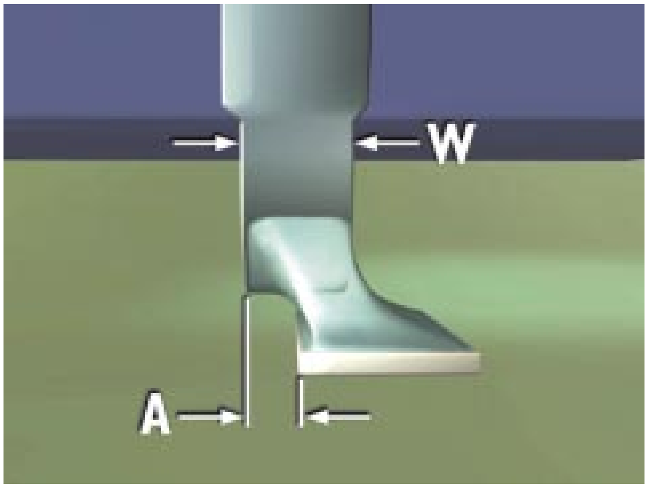

Figure 12-91

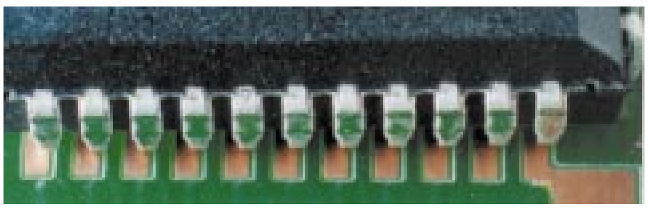

Figure 12-92

Acceptable - Class 1,2

- Side overhang (A) equal to or less than 50% lead width (W).

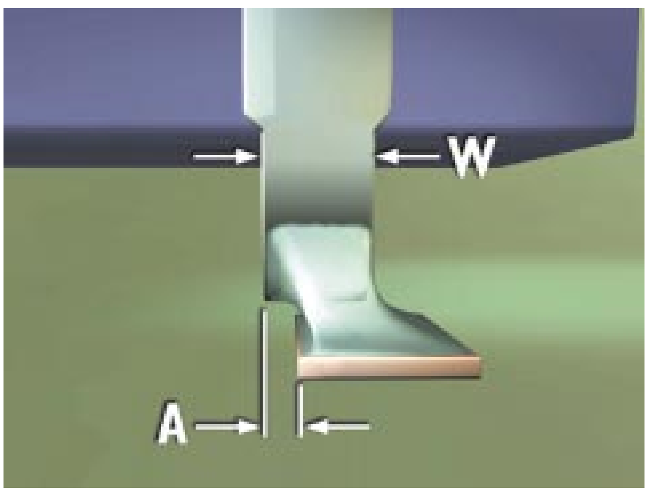

Figure 12-93

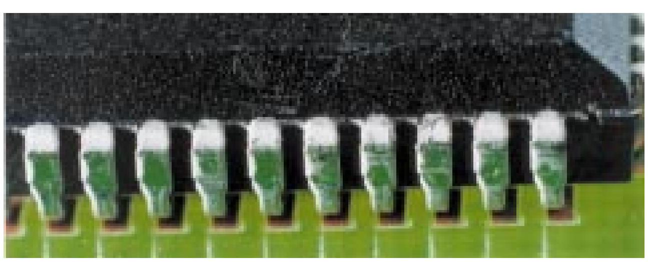

Figure 12-94

Acceptable - Class 3

- Side overhang (A) equal to or less than 25% lead width (W).

12.2.7.1 J Leads, Side Overhang (A) (cont.)

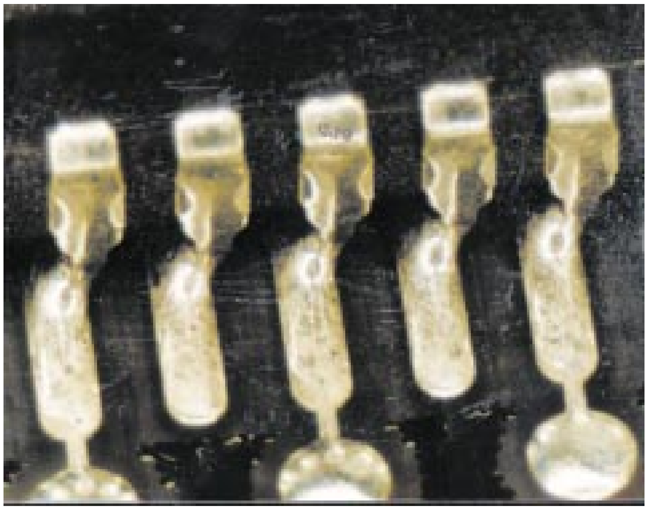

Figure 12-95

Defect - Class 1,2

- Side overhang exceeds 50% lead width (W).

Defect - Class 3

- Side overhang exceeds 25% lead width (W).

12.2.7.2 J Leads, Toe Overhang (B)

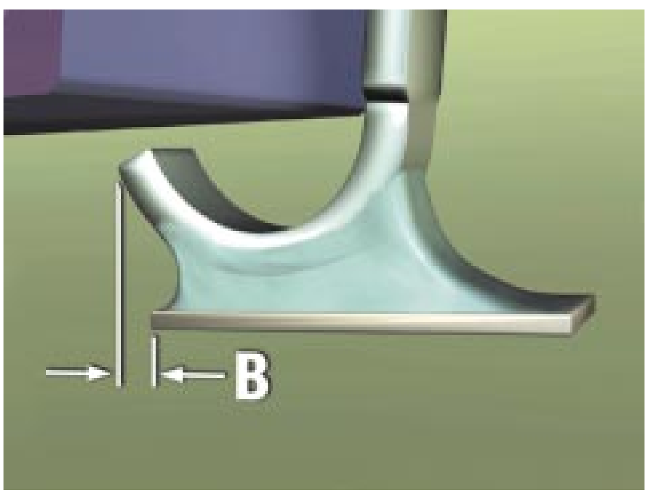

Figure 12-96

Acceptable - Class 1,2,3

- Toe overhang (B) is an unspecified parameter.

12.2.7.3 J Leads, End Joint Width (C)

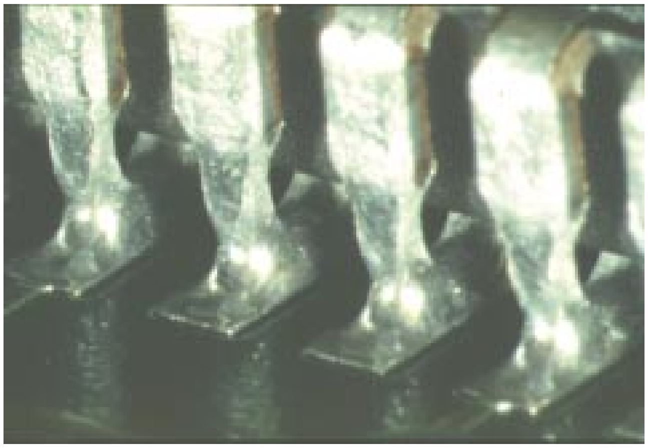

Figure 12-97

Target - Class 1,2,3

• End joint width (C) is equal to or greater than lead width (W).

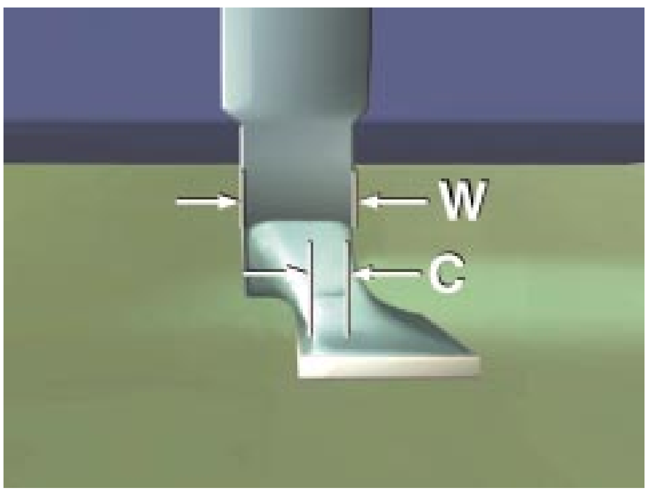

Figure 12-98

Acceptable - Class 1,2

• Minimum end joint width (C) is 50% lead width (W).

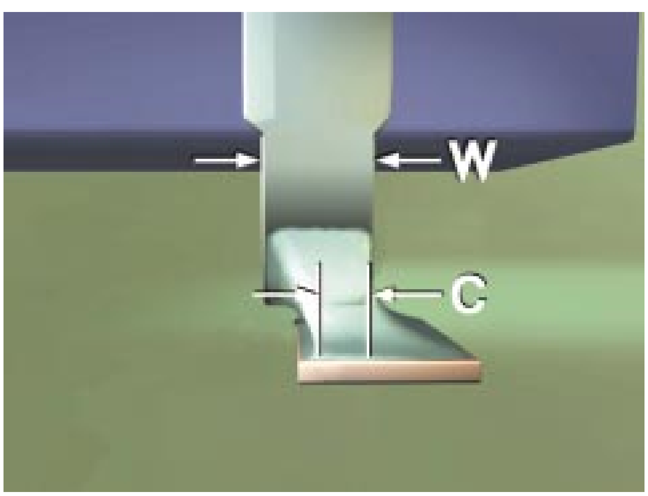

Figure 12-99

Acceptable - Class 3

• Minimum end joint width (C) is 75% lead width (W).

Defect - Class 1,2

• Minimum end joint width (C) is less than 50% lead width (W).

Defect - Class 3

• Minimum end joint width (C) is less than 75% lead width (W).

12.2.7.4 J Leads, Side Joint Length (D)

Figure 12-100

Target - Class 1,2,3

• Side joint length (D) is greater than 200% lead width (W).

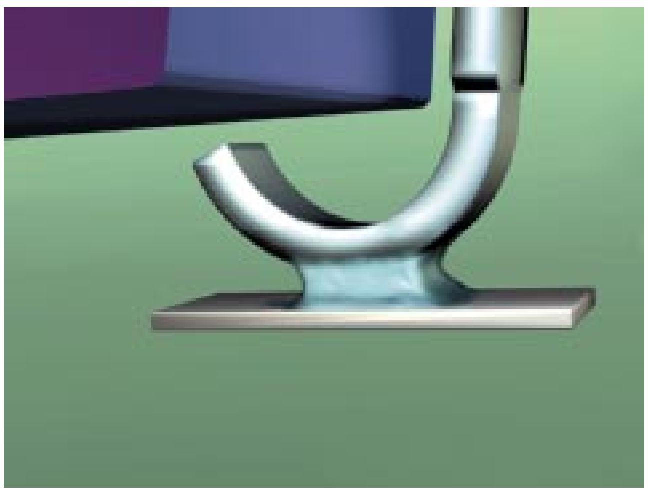

Figure 12-101

Acceptable - Class 1

• Properly wetted fillet.

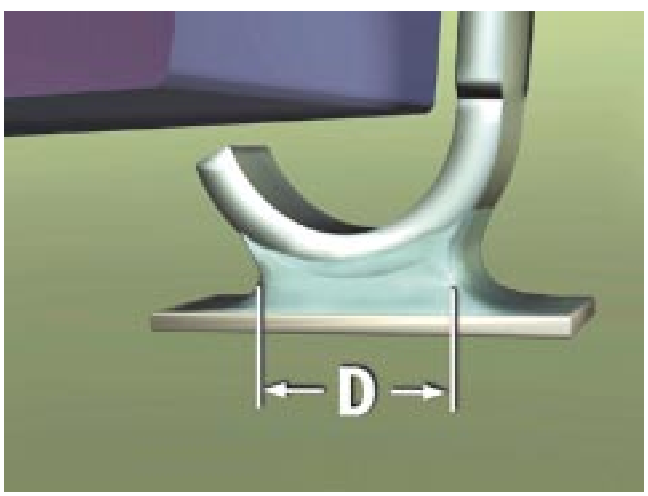

Figure 12-102

Acceptable - Class 2,3

• Side joint length (D) exceeds 150% lead width (W).

Defect - Class 2,3

• Side joint fillet (D) less than 150% lead width (W).

Defect - Class 1,2,3

• A properly wetted fillet is not evident.

12.2.7.5 J Leads, Maximum Fillet Height (E)

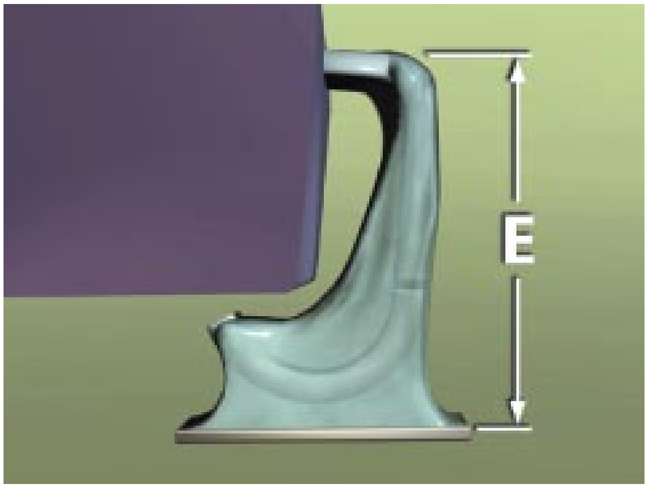

Figure 12-103

Acceptable - Class 1,2,3

• Solder fillet does not touch package body.

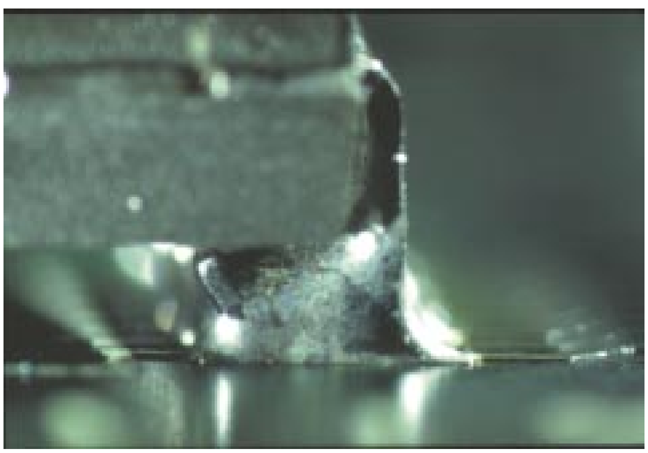

Figure 12-104

Defect - Class 1,2,3

• Solder fillet touches package body.

12.2.7.6 J Leads, Minimum Heel Fillet Height (F)

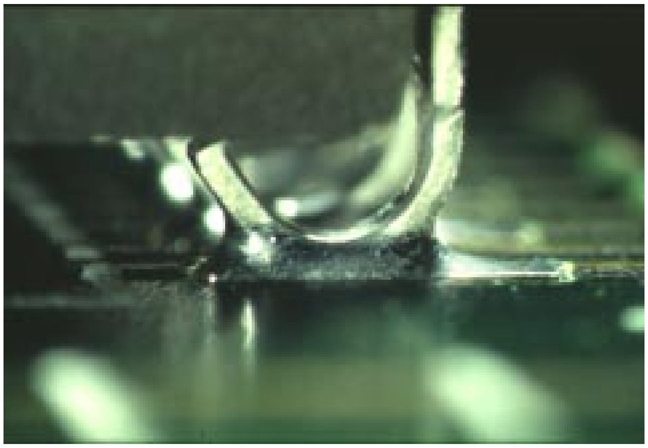

Figure 12-105

Target - Class 1,2,3

- Heel fillet height (F) exceeds lead thickness (T) plus solder thickness (G).

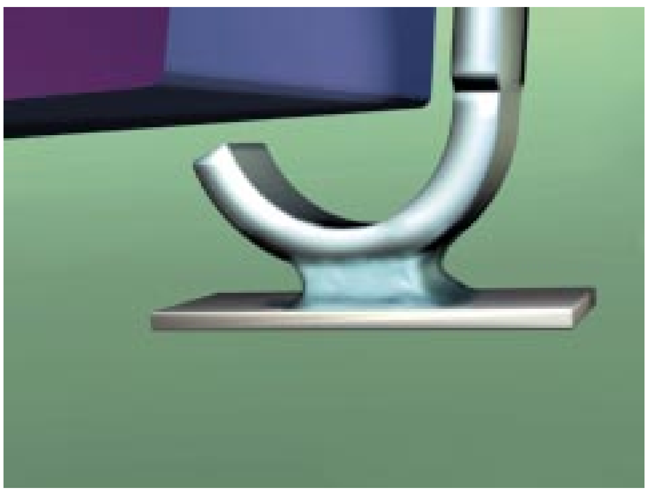

Figure 12-106

Acceptable - Class 1

- Heel fillet properly wetted.

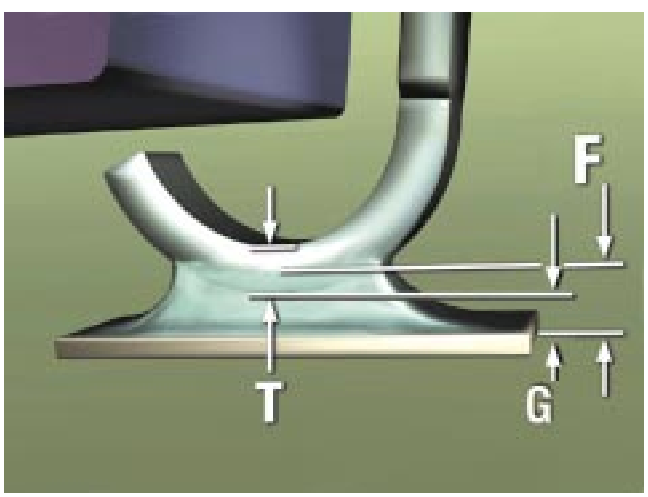

Figure 12-107

Acceptable - Class 2

- Heel fillet height (F) is minimum 50% lead thickness (T) plus solder thickness (G).

12.2.7.6 J Leads, Minimum Heel Fillet Height (F) (cont.)

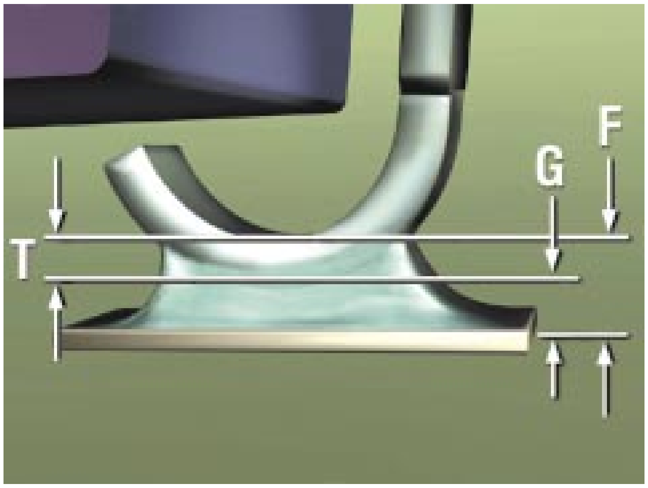

Figure 12-108

Acceptable - Class 3

- Heel fillet height (F) is at least lead thickness (T) plus solder thickness (G).

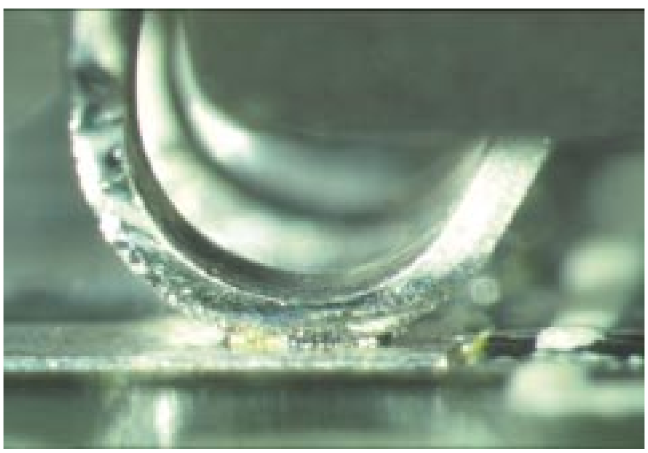

Figure 12-109

Defect - Class 1,2,3

- Heel fillet not properly wetted.

Defect - Class 2

- Heel fillet height (F) less than solder thickness (G) plus 50% lead thickness (T).

Defect - Class 3

- Heel fillet height (F) less than solder thickness (G) plus lead thickness (T).

12.2.7.7 J Leads, Solder Thickness (G)

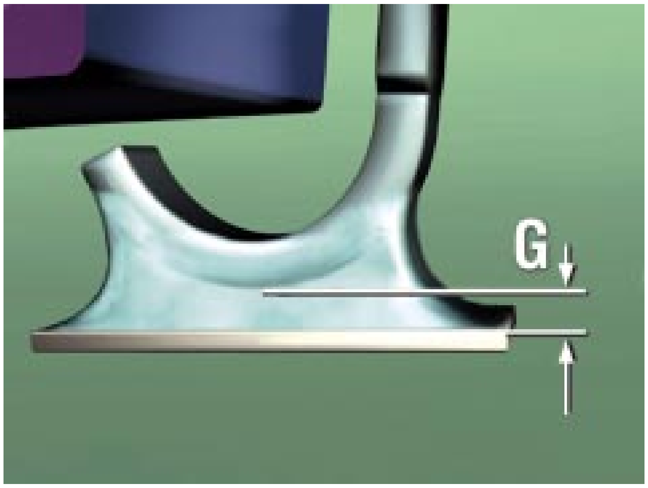

Figure 12-110

Acceptable - Class 1,2,3

• Properly wetted fillet evident.

12.2.8 Butt/I Joints

Joints formed to leads positioned perpendicular to a circuit land in a butt configuration must meet dimensional and solder fillet requirements listed below. **Butt joints are not permitted for Class 3 products.** For Class 1 and 2 product, leads not having wettable sides by design (such as leads stamped or sheared from pre-plated stock) are not required to have side fillets. However the design should permit easy inspection of wetting to the wettable surfaces.

Table 12-8 Butt/I Joint Features

Feature	Dim.
Maximum side overhang	A
Maximum toe overhang	B
Minimum end joint width	C
Minimum side joint length	D
Maximum fillet height[1]	E
Minimum fillet height	F
Solder thickness	G
Lead thickness	T
Lead width	W

Note 1. Maximum fillet may extend into the bend radius.

12.2.8.1 Butt/I Joints, Maximum Side Overhang (A)

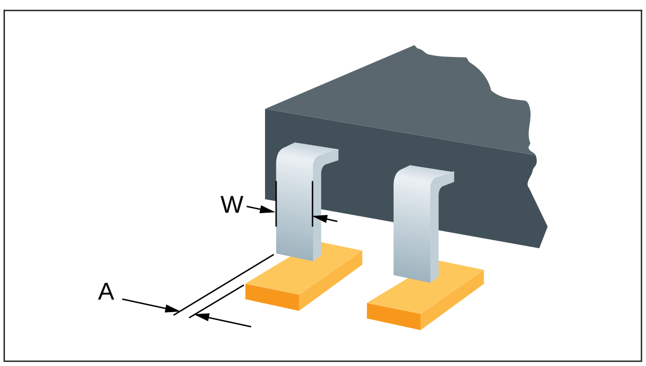

Figure 12-111

Target - Class 1,2

• No side overhang.

Acceptable - Class 1

• Overhang (A) less than 25% lead width (W).

Defect - Class 1

• Overhang (A) exceeds 25% lead width (W).

Defect - Class 2

• Any side overhang (A).

12.2.8.2 Butt/I Joints, Maximum Toe Overhang (B)

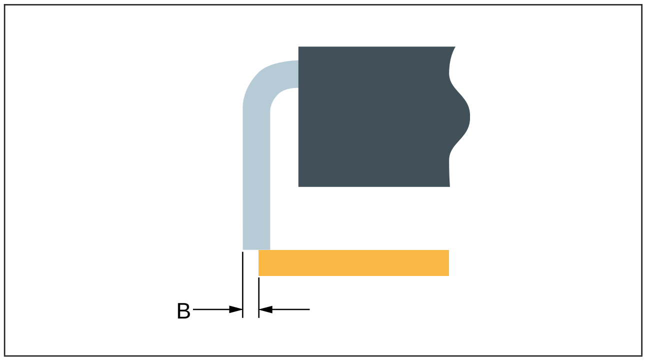

Figure 12-112

Defect - Class 1,2

• Any toe overhang (B).

12.2.8.3 Butt/I Joints, Minimum End Joint Width (C)

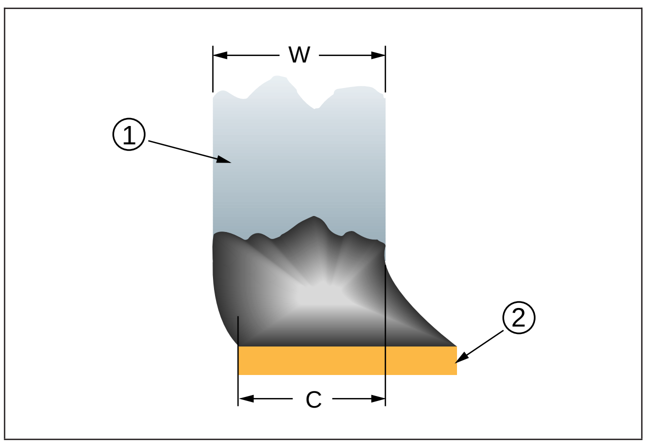

Figure 12-113
1. Lead
2. Land

Target - Class 1,2

• End joint width (C) is greater than lead width (W).

Acceptable - Class 1,2

• End joint width (C) is minimum 75% lead width (W).

Defect - Class 1,2

• End joint width (C) is less than 75% lead width (W).

12.2.8.4 Butt/I Joints, Minimum Side Joint Length (D)

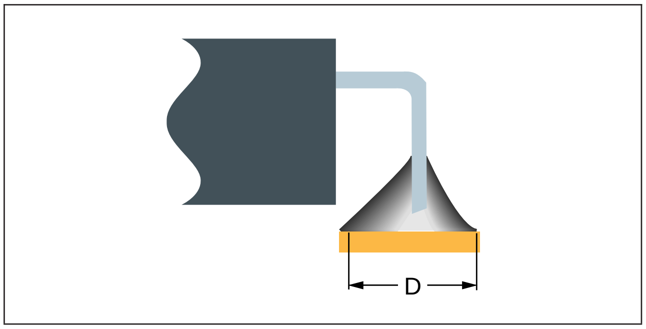

Figure 12-114

Acceptable - Class 1,2

• Minimum side joint length (D) is not a specified parameter.

12.2.8.5 Butt/I Joints, Maximum Fillet Height (E)

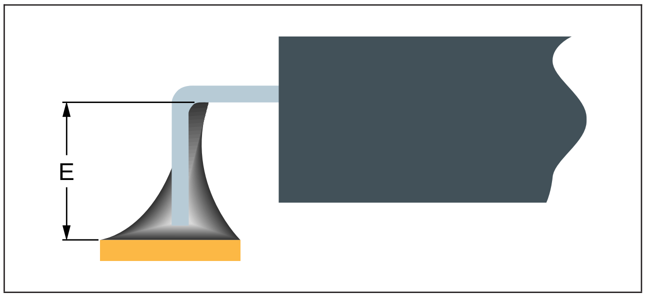

Figure 12-115

Acceptable - Class 1,2

• Properly wetted fillet evident.

Defect - Class 1,2

• No properly wetted fillet.
• Solder touches package body.

12.2.8.6 Butt/I Joints, Minimum Fillet Height (F)

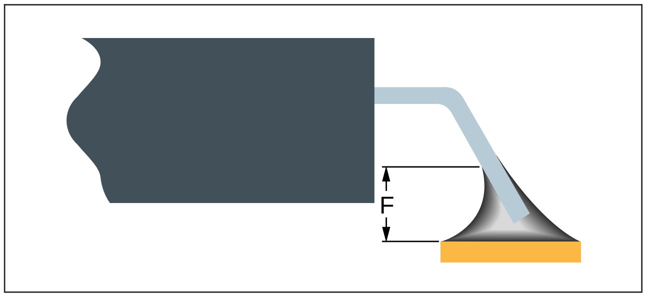

Figure 12-116

Acceptable - Class 1,2

- Fillet height (F) is minimum 0.5 mm [0.02 in].

Defect - Class 1,2

- Fillet height (F) is less than 0.5 mm [0.02 in].

12.2.8.7 Butt/I Joints, Solder Thickness (G)

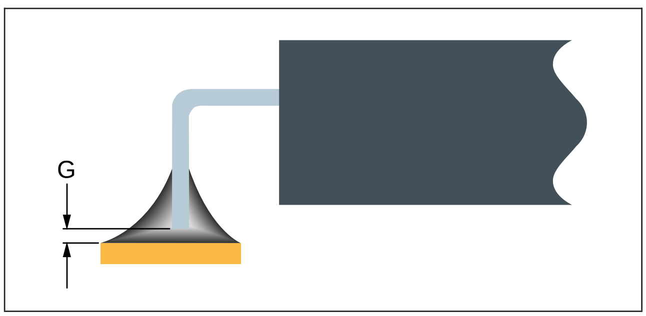

Figure 12-117

Acceptable - Class 1,2

- Properly wetted fillet evident.

12.2.9 Flat Lug Leads

Joints formed to the leads of power dissipating components with flat lug leads must meet the dimensional requirements of Table 12-9 and Figure 12-119. The design should permit easy inspection of wetting to the wettable surfaces.

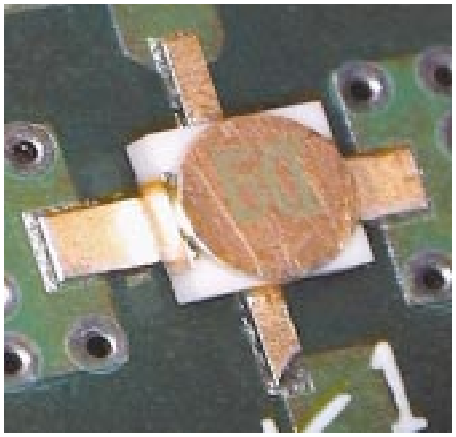

Figure 12-118

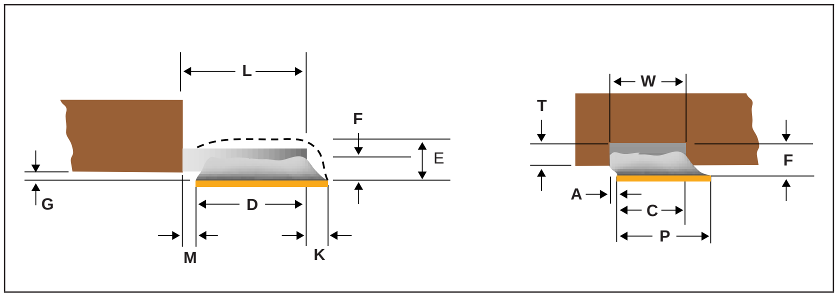

Figure 12-119

Table 12-9 Dimensional Criteria - Flat Lug Leads

Feature	Dim.	Class 1	Class 2	Class 3
Side overhang	A	50% (W) Note[1]	25% (W) Note[1]	Not permitted
Toe overhang (not shown)	B	Note[1]	Not permitted	Not permitted
Minimum end joint width	C	50% (W)	75% (W)	(W)
Minimum side joint length	D	Note[3]	(L)-(M), Note[4]	(L)-(M), Note[4]
Maximum fillet height	E	Note[2]	Note[2]	(G) + (T) + 1.0 mm
Minimum fillet height	F	Note[3]	Note[3]	(G) + (T)
Solder fillet thickness	G	Note[3]	Note[3]	Note[3]
Maximum land protrusion	K	Note[2]	Note[2]	Note[2]
Lead length	L	Note[2]	Note[2]	Note[2]
Maximum gap	M	Note[2]	Note[2]	Note[2]
Land width	P	Note[2]	Note[2]	Note[2]
Lead thickness	T	Note[2]	Note[2]	Note[2]
Lead width	W	Note[2]	Note[2]	Note[2]

Note 1. **Must not** violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Properly wetted fillet **must** be evident.
Note 4. Where the lug is intended to be soldered beneath the component body and the land is designed for the purpose, the lead **shall** show evidence of wetting in the gap M.

12.2.10 Tall Profile Components Having Bottom Only Terminations

Joints formed to the termination areas of tall profile components having bottom only terminations must meet the dimensional requirements of Table 12-10 and Figure 12-120. If the height of the component exceeds the thickness of the component, the component should not be used in products subject to vibration and/or shock unless an appropriate adhesive is used to reinforce the component mounting.

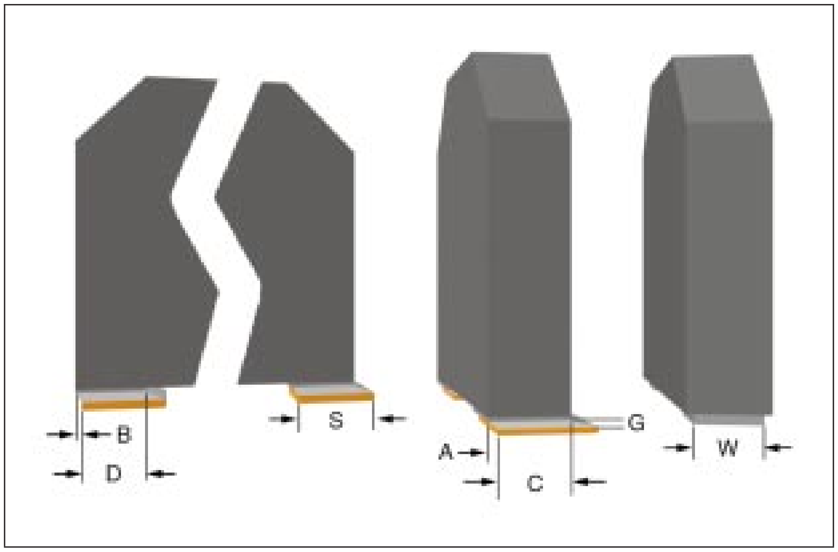

Figure 12-120

Table 12-10 Dimensional Criteria - Tall Profile Components Having Bottom Only Terminations

Feature	Dim.	Class 1	Class 2	Class 3
Side overhang	A	50% (W); Notes[1,4]	25% (W); Notes[1,4]	Not permitted; Notes[1,4]
End overhang	B	Notes[1,4]	Not permitted	Not permitted
Minimum end joint width	C	50% (W)	75% (W)	(W)
Minimum side joint length	D	Note[3]	50% (L)	75% (L)
Solder fillet thickness	G	Note[3]	Note[3]	Note[3]
Land length	S	Note[2]	Note[2]	Note[2]
Land width	W	Note[2]	Note[2]	Note[2]

Note 1. **Must not** violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Properly wetted fillet **must** be evident.
Note 4. As a function of the component design, the termination may not extend to the component edge, and the component body may overhang the PWB land area. The component solderable termination area **must not** overhang PWB land area.

12.2.11 Inward Formed L-Shaped Ribbon Leads

Joints formed to components having inward formed L-shaped lead terminations shall meet the dimensional and solder fillet requirements of Table 12-11 and Figure 12-124. The design should permit easy inspection of wetting to the wettable surfaces.

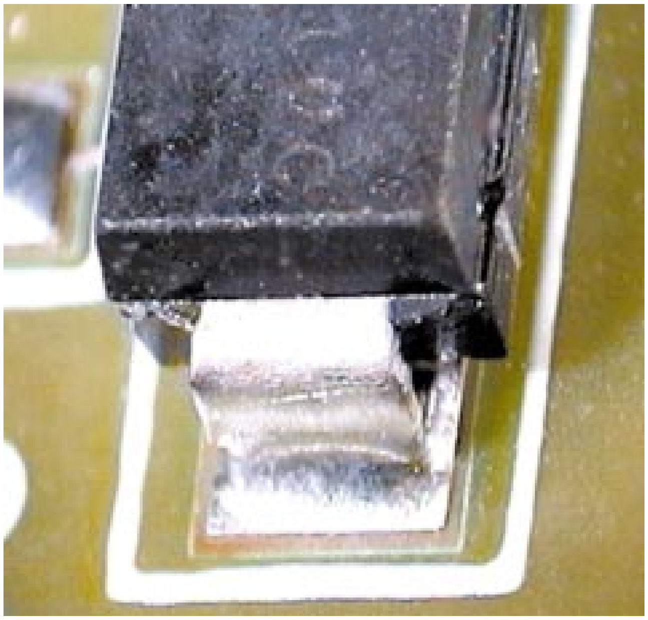

Figure 12-121

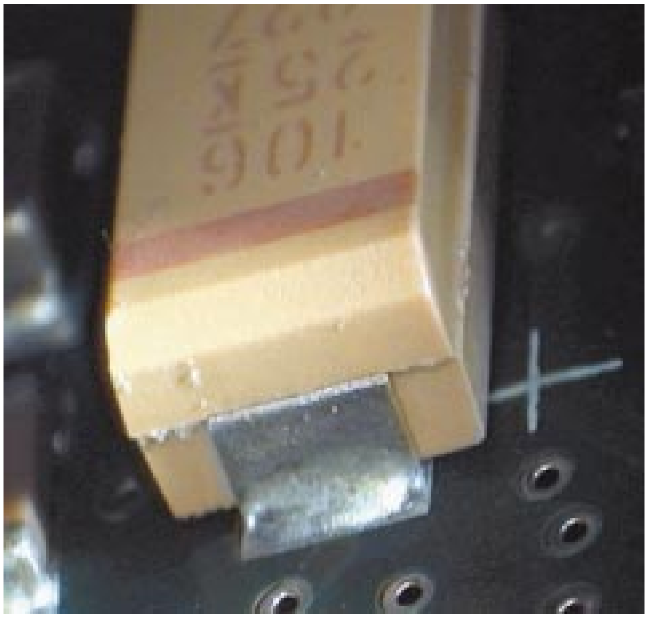

Figure 12-122

Examples of inward formed L-shaped ribbon lead components.

12.2.11 Inward Formed L-Shaped Ribbon Leads (cont.)

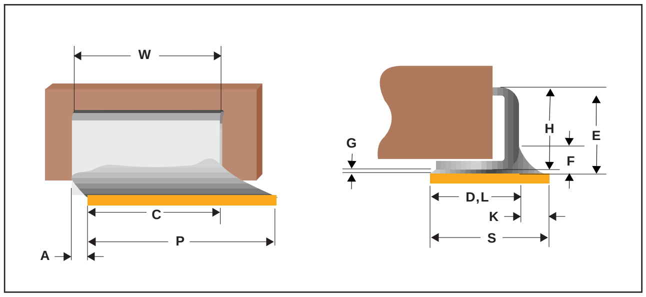

Figure 12-123

Table 12-11 Dimensional Criteria - Inward Formed L-Shaped Ribbon Leads[5]

Feature	Dim.	Class 1	Class 2	Class 3
Maximum side overhang	A	50% (W) Notes[1,5]	50% (W) Notes[1,5]	25% (W) or 25% (P) whichever is less; Notes[1,5]
Maximum toe overhang (not shown)	B	Note[1]	Not Permitted	Not Permitted
Minimum end joint width	C	50% (W)	50% (W)	75% (W) or 75% (P), whichever is less
Minimum side joint length	D	Note[3]	50% (L)	75% (L)
Maximum fillet height	E	(H) + (G) Note[4]	(H) + (G) Note[4]	(H) + (G) Note[4]
Minimum fillet height	F	Note[3]	(G) + 25% (H) or (G) + 0.5 mm [0.0197 in], whichever is less	(G) + 25% (H) or (G) + 0.5 mm [0.0197 in], whichever is less
Solder fillet thickness	G	Note[3]	Note[3]	Note[3]
Lead height	H	Note[2]	Note[2]	Note[2]
Minimum land extension	K	Note[5]	Note[5]	50% (H) or 0.5 mm [0.0197 in], whichever is less
Lead length	L	Note[2]	Note[2]	Note[2]
Pad width	P	Note[2]	Note[2]	Note[2]
Land length	S	Note[2]	Note[2]	Note[2]
Lead width	W	Note[2]	Note[2]	Note[2]

Note 1. **Must not** violate minimum electrical clearance.
Note 2. Unspecified parameter or variable in size as determined by design.
Note 3. Properly wetted fillet **must** be evident.
Note 4. Solder **shall not** contact the component body on the inside of the lead bend.
Note 5. Where a lead has two prongs, the joint to each prong **shall** meet all the specified requirements.

Figure 12-124

Defect - Class 1,2,3

• Insufficient fillet height.

12.2.12 Area Array/Ball Grid Array

A BGA inspection criterion assumes that the reflow process has been qualified to ensure proper reflow temperatures have been achieved under the component. X-ray may be used as an inspection tool.

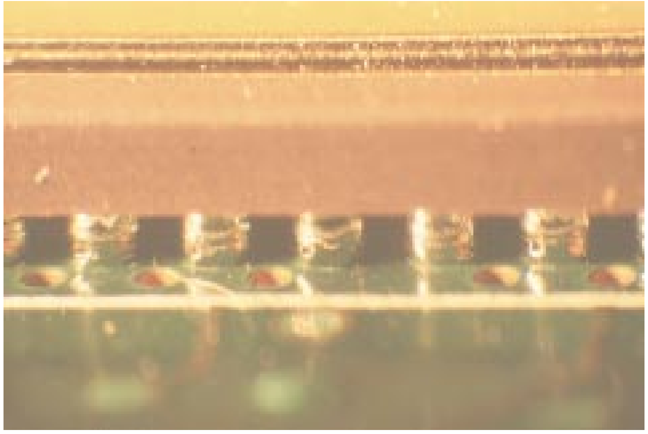

Figure 12-125

Target - Class 1,2,3

- Solder terminations are smooth and rounded, with a clearly defined boundary, have no voids, are of the same diameter, volume, darkness and contrast.
- Registration is straight and shows no pad overhang or rotation.
- No solder balls present.

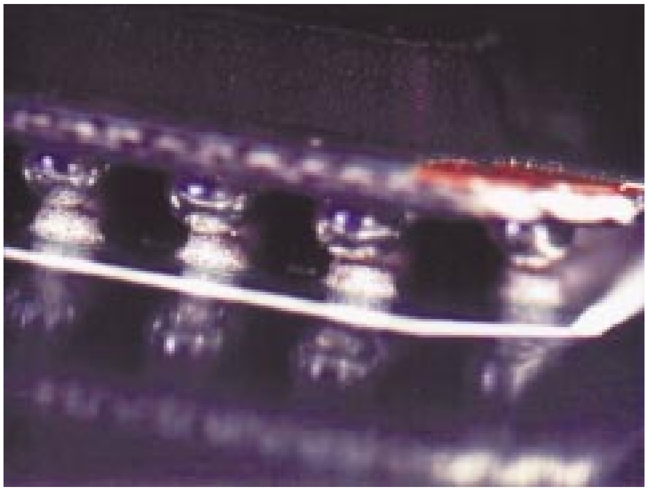

Figure 12-126

Without substantial documented reliability data at the time of publication of this revision, the criteria presented below were established by the experience and consensus of the IPC-A-610 committee, and they are not based on significant reliability data. This is suggested as a starting point for acceptance criteria.

Acceptable - Class 1,2,3

- Less than 25% overhang.

Process Indicator - Class 2,3

- 25-50% overhang.

Defect - Class 1,2,3

- More than 50% overhang.

12.2.12 Area Array/Ball Grid Array (cont.)

Process Indicator - Class 1,2,3

- Solder balls bridging up to 25% of the distance between any two terminations.
- Solder balls that do not violate minimum electrical clearance.

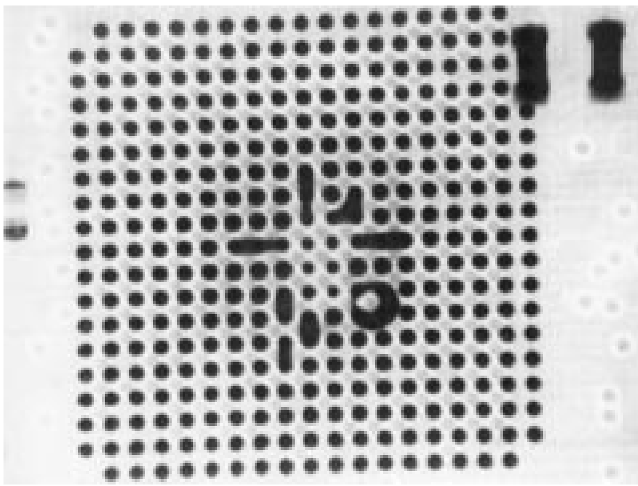

Figure 12-127

Defect - Class 1,2,3

- Solder bridge.
- Dark spots in x-ray view that bridge between solder joints (provided they cannot be attributed to circuitry or components underneath the BGA.)
- Solder opens.
- Missing solder.
- Solder balls(s) that bridge more than 25% of the distance between the leads.
- Solder ball(s) that violate the minimum electrical clearance.
- Solder joint boundary lacks definition and appears fuzzy or blends in with background (may indicate insufficient reflow).

Process development such as those listed below for BGA attachment criteria is critical for performance of the attachment technology. IPC-SM-785 (or equivalent) provides guidelines for accelerated reliability testing of surface mount attachments.

The following guidelines are provided as assessment criteria for the attachment technology process. Without substantial documented reliability data at the time of publication of this revision, no acceptability criteria are provided.

Acceptable - Class 1,2,3

- Less than 10% voiding in the ball to board interface.

Process Indicator - Class 2,3

- 10-25% voiding in the ball to board interface.

Voiding in the BGA solder ball to board interconnection up to 25% may or may not be a reliability issue and should be determined in your process development.

BGA solder joint reliability studies performed at some industry locations show that limited voiding in BGA balls does not impact long term reliability.

Defect - Class 1,2,3

- More than 25% voiding in the ball to board interface.

12.2.12 Area Array/Ball Grid Array (cont.)

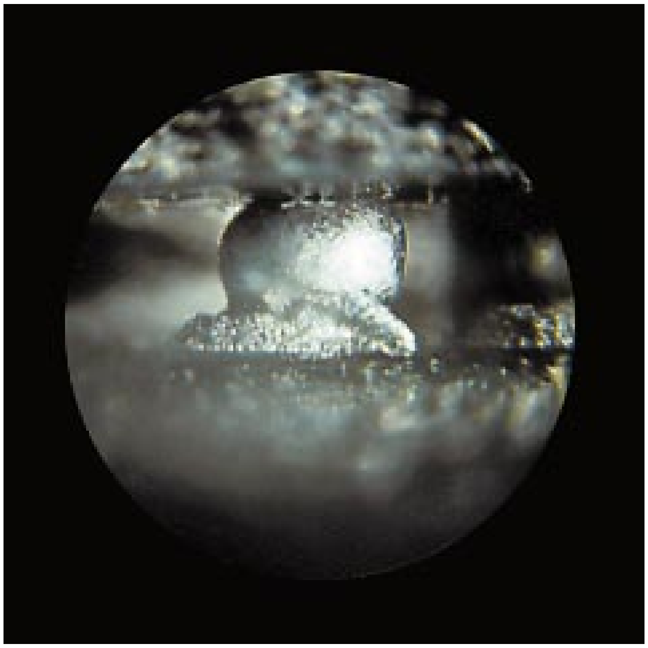

Figure 12-128

Defect - Class 1,2,3

- Incomplete solder reflow of solder paste.

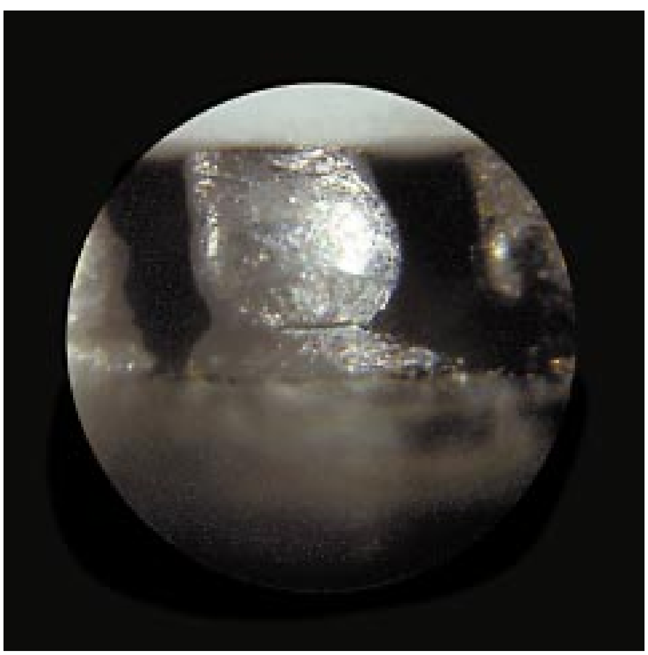

Figure 12-129

Defect - Class 1,2,3

- Fractured solder connection.

12.3 Chip Components - Termination Variations

12.3.1 Chip Components – Termination Variations – Three or Five Side Terminations - Mounting on Side

Side mounting (billboarding) of rectangular chip components is not acceptable for Class 3.

Figure 12-130

Acceptable - Class 1,2

- Rectangular chip component mounted on its side provided the following are met:
  - Maximum chip component dimensions:
    Length ≤3 mm [0.118 in]
    Width ≤1.5 mm [0.0591]
  - Chip component is surrounded by taller components.
  - No more than five (5) chip components on each assembly are mounted sideways.
  - Complete wetting at land or end cap metallization.

Note: This criteria should be considered before application to high frequency assemblies.

12.3.2 Chip Components – Termination Variations – Deposited Electrical Elements – Mounting Upside Down

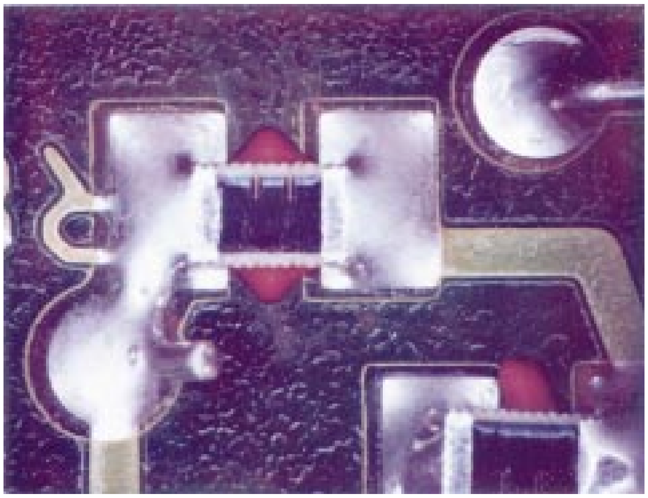

Figure 12-131

Target - Class 1,2,3

- Element of chip component with exposed deposited electrical element is mounted away from the board.

Figure 12-132

Acceptable - Class 1
Process Indicator - Class 2,3

- Element of chip component with exposed deposited electrical element is mounted toward the board.

12.4 SMT Soldering Anomalies

The defect examples in the following pictures should not be interpreted as a complete listing of all possible defects. These are representative examples only.

12.4.1 SMT Soldering Anomalies – Tombstoning

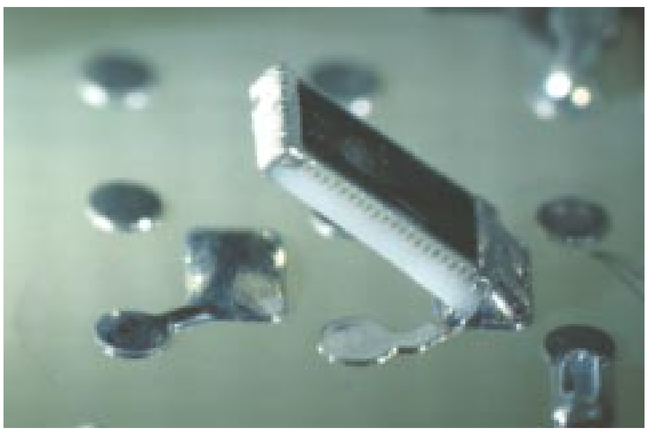

Figure 12-133

Defect - Class 1,2,3

- Chip components standing on their terminal end (tombstoning).

12.4.2 SMT Soldering Anomalies – Coplanarity

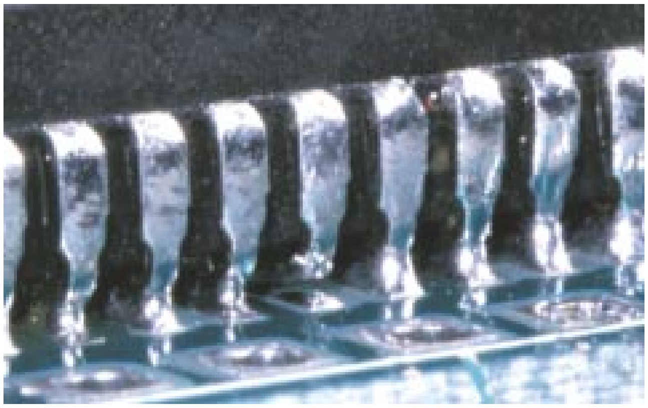

Figure 12-134

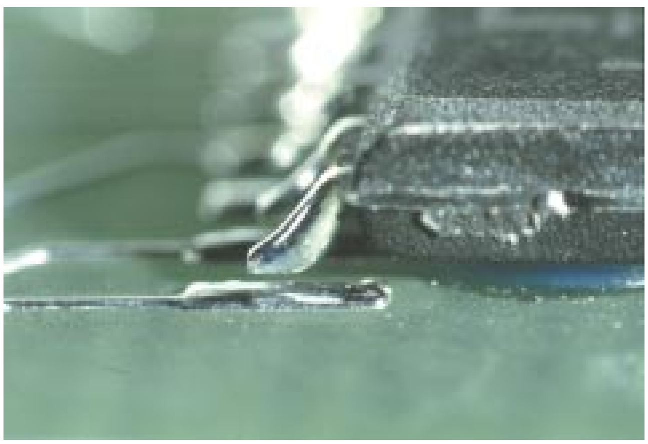

Figure 12-135

Defect - Class 1,2,3

- One lead or series of leads on component is out of alignment and fails to make proper contact with the land.

12.4.3 SMT Soldering Anomalies – Reflow of Solder Paste

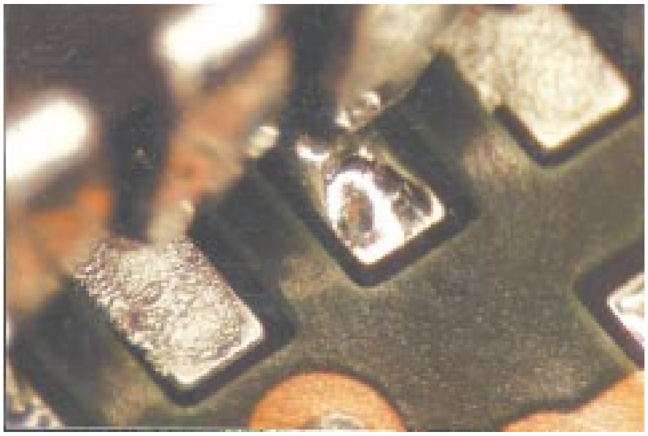

Figure 12-136

Defect - Class 1,2,3

- Incomplete reflow of solder paste.

12.4.4 SMT Soldering Anomalies – Nonwetting

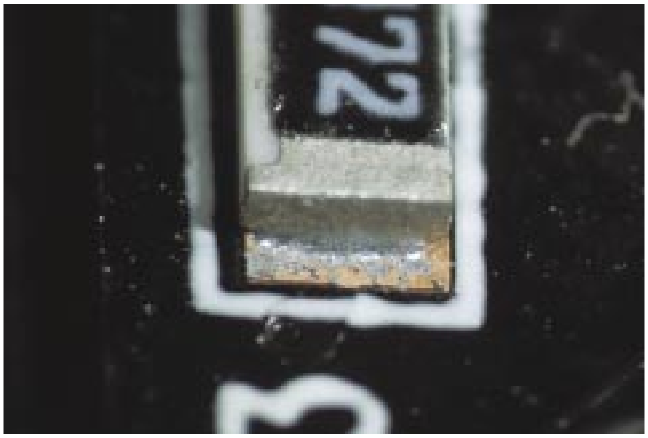

Figure 12-137

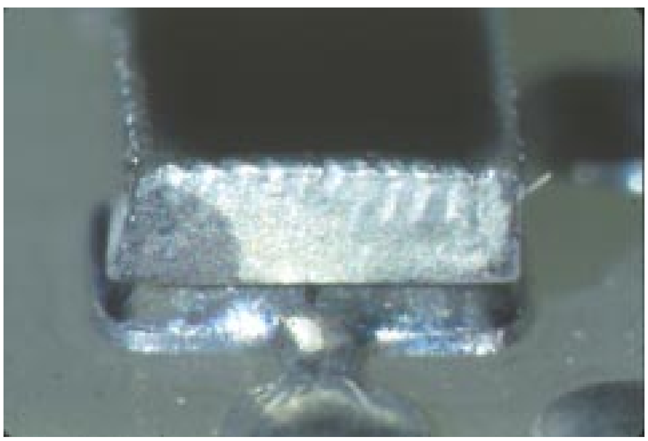

Figure 12-138

Defect - Class 1,2,3

• Solder has not wetted to the land or termination.

12.4.5 SMT Soldering Anomalies – Dewetting

Molten solder wets surface then pulls back, leaving a thin film of solder covering the metal in some areas, and irregular mounds of solder in others.

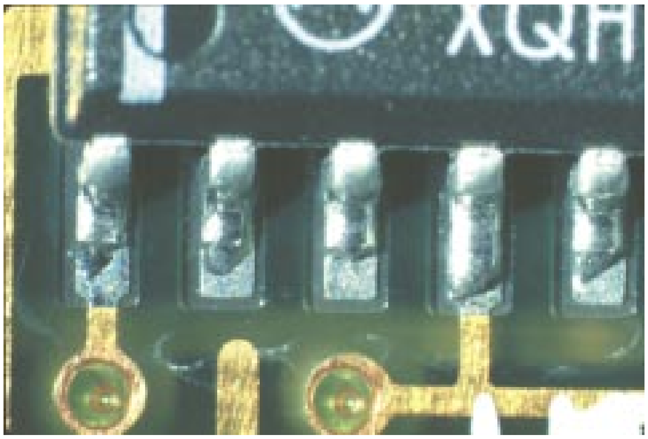

Figure 12-139

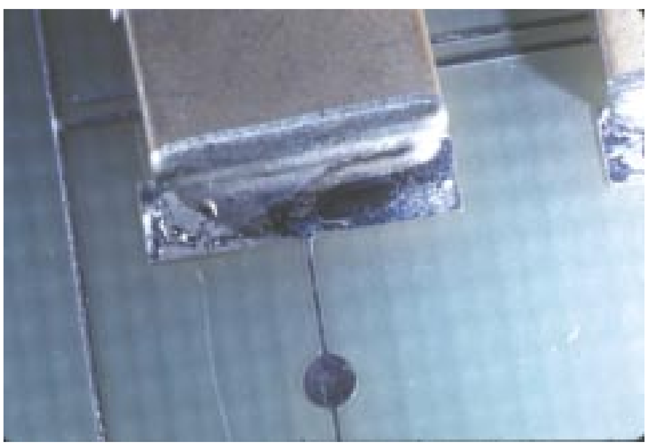

Figure 12-140

Defect - Class 1,2,3

• Does not meet solder joint criteria of 12.2.

12.4.6 SMT Soldering Anomalies – Disturbed Solder

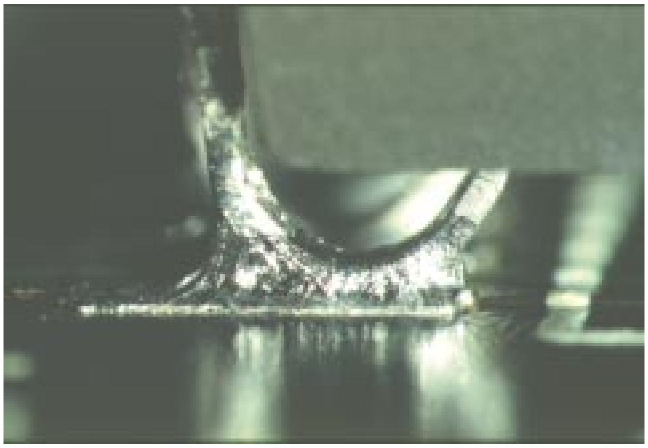

Figure 12-141

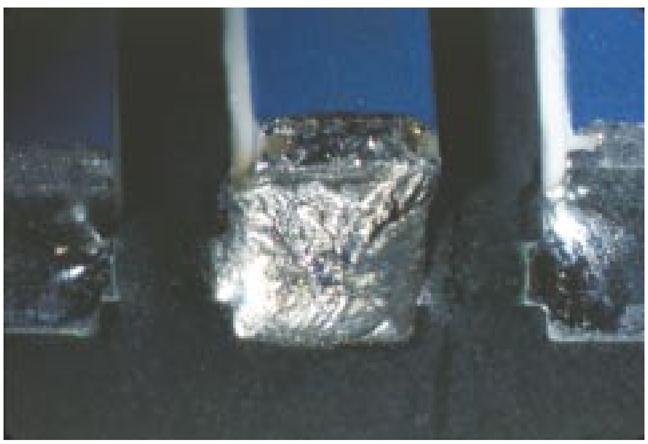

Figure 12-142

Defect - Class 1,2,3

- Characterized by stress lines from movement in the connection while solidifying.

12.4.7 SMT Soldering Anomalies – Fractured Solder

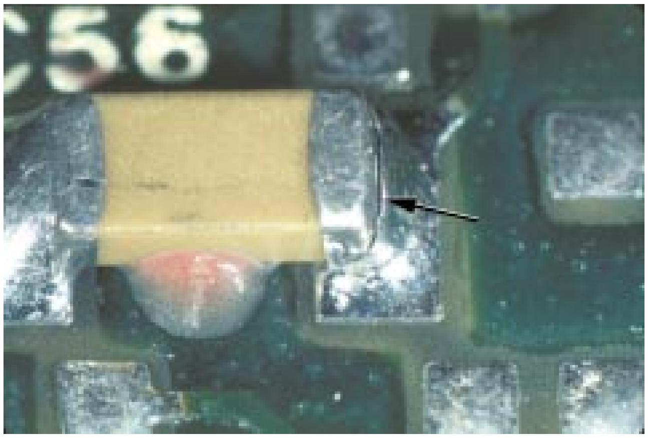

Figure 12-143

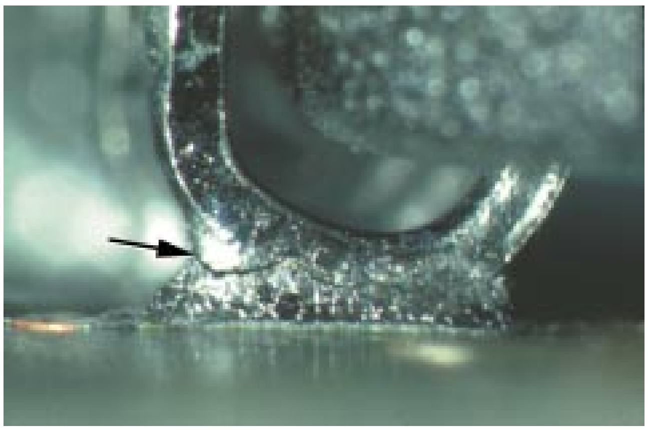

Figure 12-144

Defect - Class 1,2,3

- Fractured or cracked solder.

12.4.8 SMT Soldering Anomalies – Pinholes/Blowholes

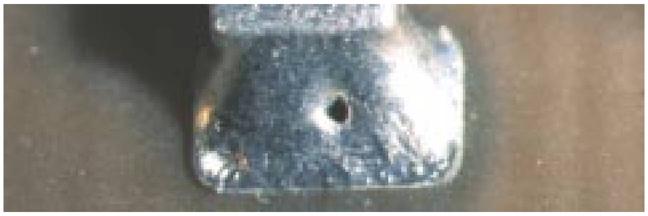

Figure 12-145

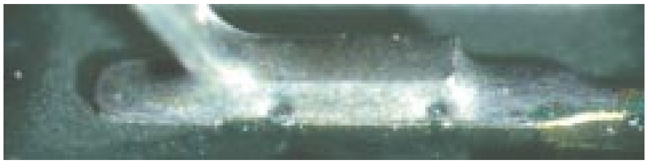

Figure 12-146

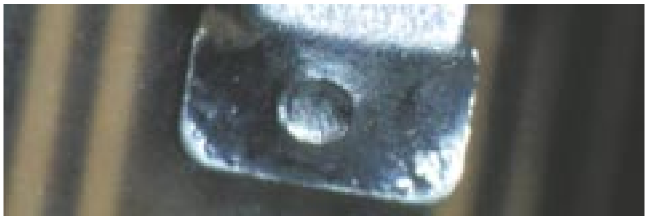

Figure 12-147

Figure 12-148

Acceptable - Class 1
Process Indicator - Class 2,3

- Blowholes, pinholes, voids, etc., are process indicators provided the solder connection meets the requirements of 12.2.

12.4.9 SMT Soldering Anomalies – Bridging

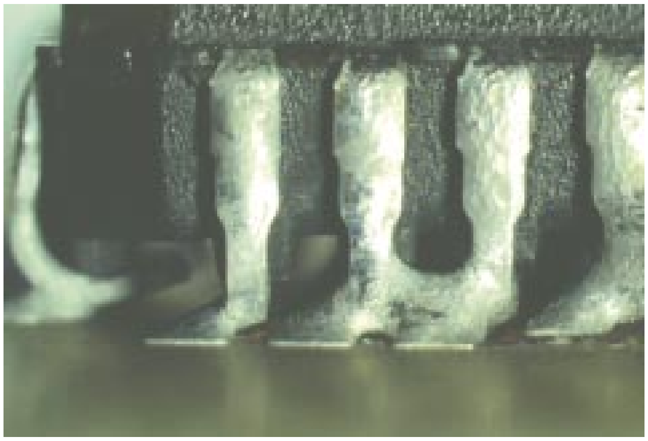

Figure 12-149

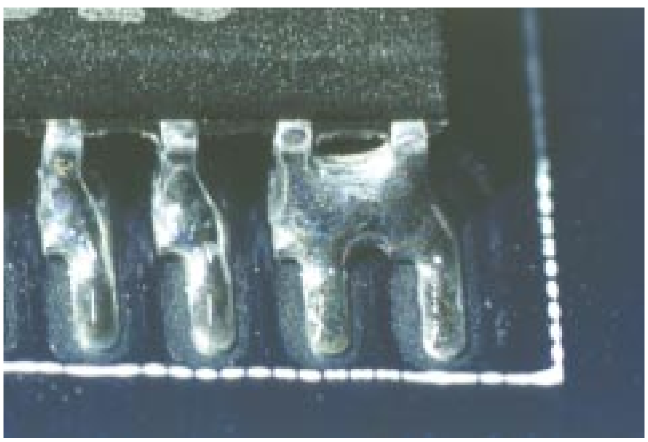

Figure 12-150

Figure 12-151

Defect - Class 1,2,3

- A solder connection across conductors that should not be joined.

12.4.10 SMT Soldering Anomalies – Solder Balls/Solder Fines

Solder balls are spheres of solder that remain after the soldering process. Solder fines are typically small balls of the original solder paste metal screen size that have splattered around the connection during the reflow process.

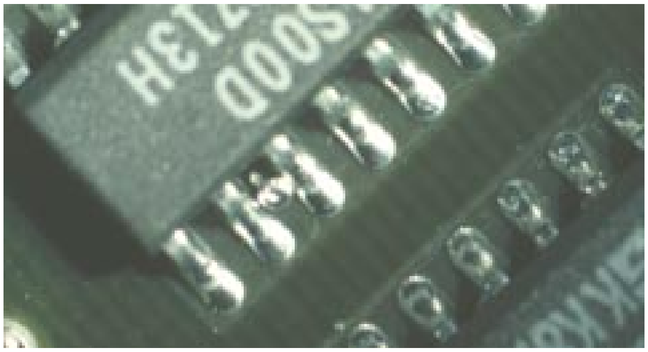

Figure 12-152

Figure 12-153

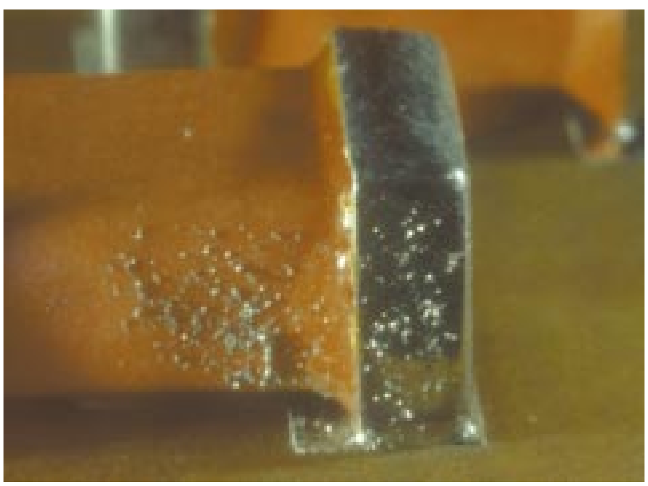

Figure 12-154

Acceptable - Class 1
Process Indicator - Class 2,3

- Entrapped or encapsulated solder balls that are within 0.13 mm [0.00512 in] of lands or conductors, or exceed 0.13 mm [0.00512 in] in diameter.
- More than five solder balls/splashes (0.13 mm [0.00512 in] or less) per 600 mm^2 [0.3 in^2].

Defect - Class 1,2,3

- Solder balls violate minimum electrical clearance.
- Solder balls not entrapped or encapsulated (e.g., no-clean residue, conformal coating), or not attached to a metal surface.

Note: Entrapped/encapsulated/attached is intended to mean normal service environment of the product will not cause a solder ball to become dislodged.

12.4.11 SMT Soldering Anomalies – Solder Webbing

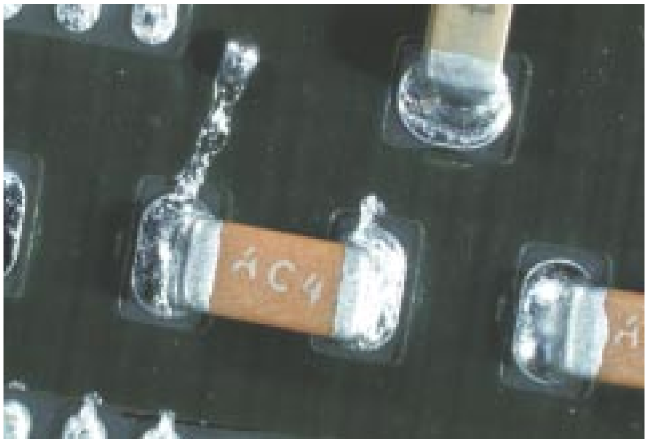

Figure 12-155

Figure 12-156

Defect - Class 1,2,3

- Solder splashes violate minimum electrical clearance.
- Solder splashes not entrapped or encapsulated (e.g., no-clean residue, conformal coating), or not attached to a metal surface.

Note: Entrapped/encapsulated/attached is intended to mean normal service environment of the product will not cause solder to become dislodged.

12.5 Component Damage

12.5.1 Component Damage – Cracks and Chip-Outs

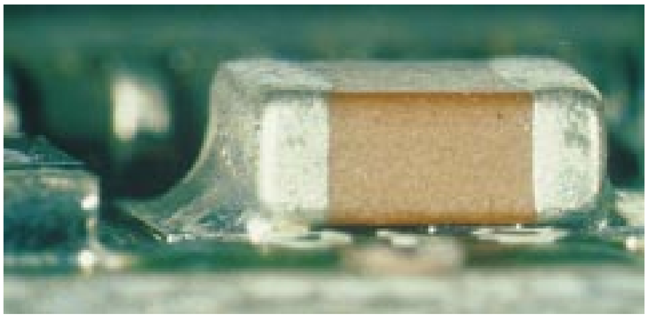

Figure 12-157

Target - Class 1,2,3

- No nicks, cracks, or stress fractures.

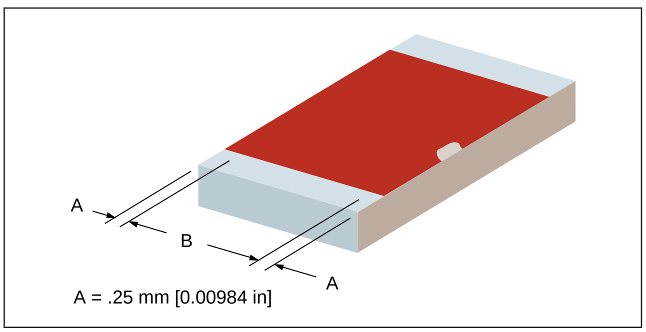

Figure 12-158

Acceptable - Class 1,2,3

- For chip resistors, any chip-outs (nick) of the top surface (adhesive coating) of 1206 and larger component is less than 0.25 mm [0.00984 in] from the edge of the component.
- No damage to the resistive element in area B.

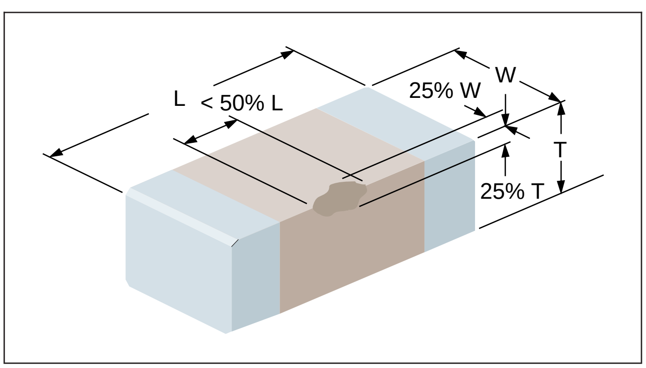

Figure 12-159

Acceptable - Class 1,2

- Nicks or chip-outs not greater than dimensions stated in Table 12-13, each considered separately.

Table 12-13 Chip-Out Criteria

(T)	25% of the thickness
(W)	25% of the width
(L)	50% of the length

12.5.1 Component Damage – Cracks and Chip-Outs (cont.)

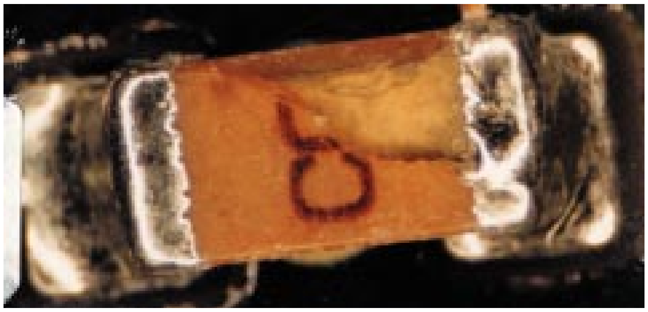

Figure 12-160

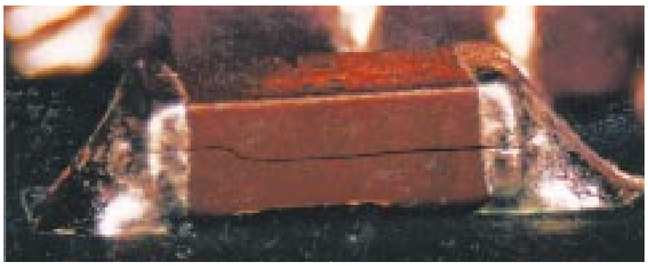

Figure 12-161

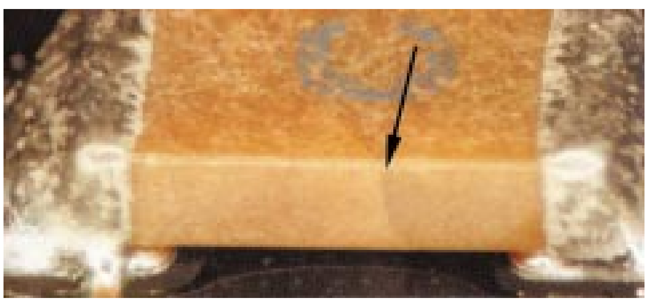

Figure 12-162

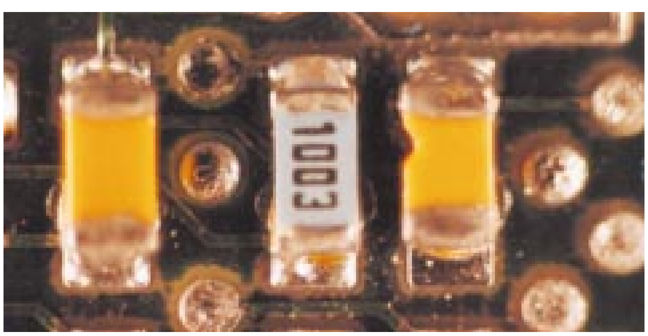

Figure 12-163

Defect - Class 1,2,3

- Any nick or chip-out that exposes the electrodes.
- Cracks, nicks or any type of damage in glass bodied components.
- Any chip-outs in resistive elements.
- Any cracks or stress fractures.

12.5.1 Component Damage – Cracks and Chip-Outs (cont.)

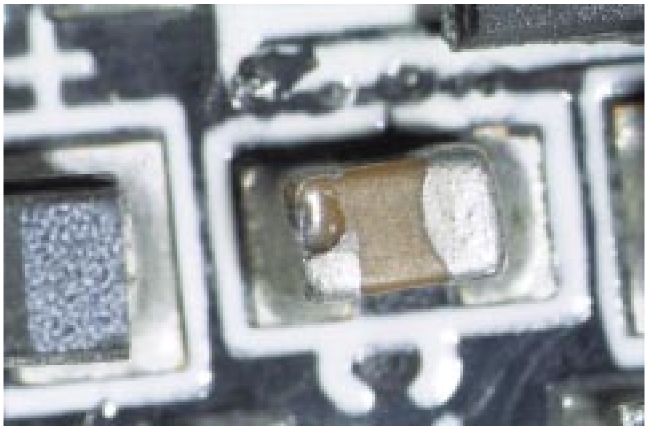

Figure 12-164

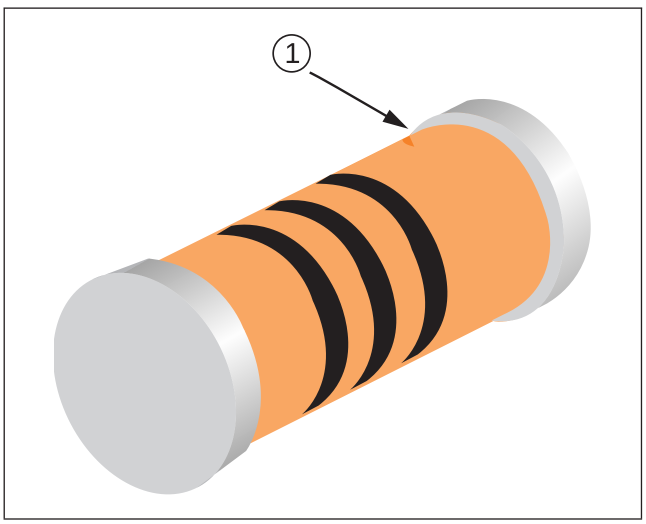

Figure 12-165
1. Nick

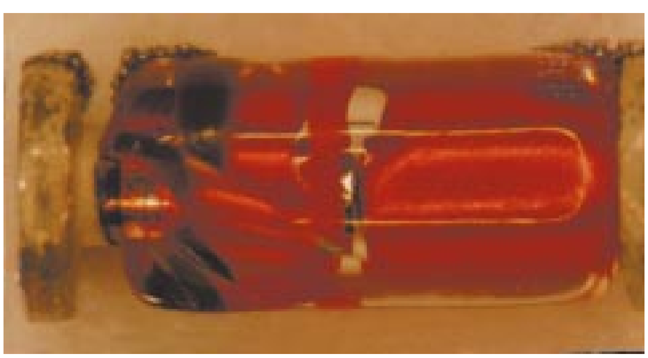

Figure 12-166

12.5.2 Component Damage – Metallization

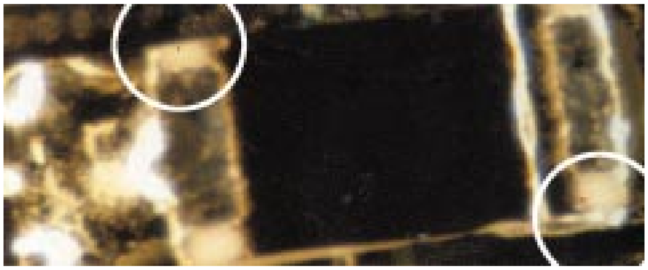

Figure 12-167

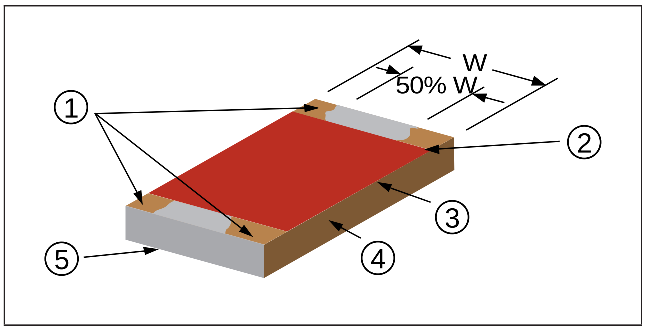

Figure 12-168

1. Metallization missing
2. Adhesive coating
3. Resistive element
4. Substrate (ceramic/alumina)
5. Terminal end

Acceptable - Class 1,2,3

- Maximum of 50% of metallization loss of top end area (for each terminal end).

Figure 12-169

Defect - Class 1,2,3

- Irregular shapes exceeding maximum or minimum dimensions for that component type.

Figure 12-170

Defect - Class 1,2,3

- Metallization loss exceeds 50% of top area.

12.5.3 Component Damage – Leaching

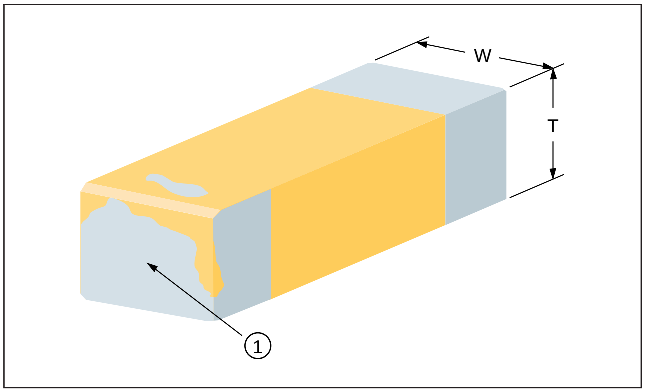

Figure 12-171
1. Leaching

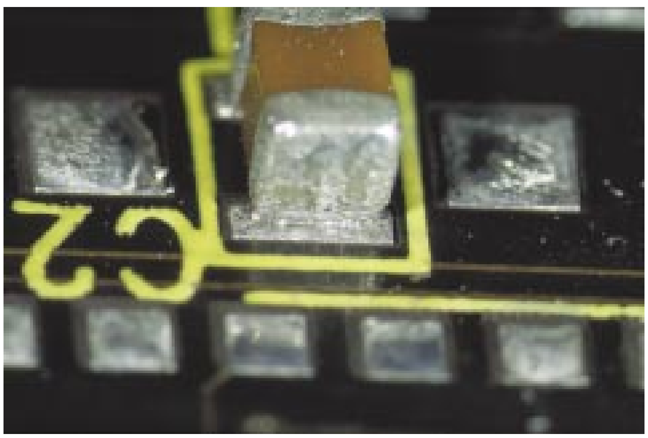

Figure 12-172

Acceptable - Class 1,2,3

- Leaching on any edge less than 25% of the component width (W) or the component thickness (T).

Defect - Class 1,2,3

- Leaching of the terminal end face exposing the ceramic.
- Leaching exceeding 25% of component width (W) or component thickness (T).

Electrical Conductor Spacing

NOTE: Appendix A is quoted from IPC-2221 Generic Standard on Printed Board Design (February 1998) and is provided for information only. It is current as of publication date of this document. The user has the responsibility to determine the most current revision level of IPC-2221 and specify the specific application to their product. Paragraph and table numbers are from IPC-2221.

The following statement from IPC-2221 applies to this Appendix ONLY: **1.4 Interpretation – "Shall,"** the imperative form of the verb, is used throughout this standard [IPC-A-610C Appendix A] whenever a requirement is intended to express a provision that is mandatory.

IPC-2221 – **6.3 Electrical Clearance** Spacing between conductors on individual layers should be maximized whenever possible. The minimum spacing between conductors, between conductive patterns, layer to layer conductive spaces (z-axis), and between conductive materials (such as conductive markings or mounting hardware) and conductors **shall** be in accordance with Table 6-1, and defined on the master drawing. For additional information on process allowances effecting electrical clearance, see Section 10.

When mixed voltages appear on the same board and they require separate electrical testing, the specific areas **shall** be identified on the master drawing or appropriate test specification. When employing high voltages and especially AC and pulsed voltages greater than 200 volts potential, the dielectric constant and capacitive division effect of the material must be considered in conjunction with the recommended spacing.

For voltages greater than 500V, the (per volt) table values must be added to the 500V values. For example, the electrical spacing for a Type B1 board with 600V is calculated as:

600V - 500V = 100V
0.25 mm + (100V x 0.0025 mm)
= 0.50 mm clearance

When, due to the criticality of the design, the use of other conductor spacings is being considered, the conductor spacing on individual layers (same plane) **shall** be made larger than the minimum spacing required by Table 6-1 whenever possible. Board layout should be planned to allow for the maximum spacing between external layer conductive areas associated with high impedance or high voltage circuits. This will minimize electrical leakage problems resulting from condensed moisture or high humidity. Complete reliance on coatings to maintain high surface resistance between conductors **shall** be avoided.

IPC-2221 – **6.3.1 B1-Internal Conductors** Internal conductor-to-conductor, and conductor-to-plated-through hole electrical clearance requirements at any elevation. See Table 6-1.

IPC-2221 – **Table 6-1 Electrical Conductor Spacing**

Voltage Between Conductors (DC or AC Peaks)	Minimum Spacing						
	Bare Board				Assembly		
	B1	B2	B3	B4	A5	A6	A7
0-15	0.05 mm	0.1 mm	0.1 mm	0.05 mm	0.13 mm	0.13 mm	0.13 mm
16-30	0.05 mm	0.1 mm	0.1 mm	0.05 mm	0.13 mm	0.25 mm	0.13 mm
31-50	0.1 mm	0.6 mm	0.6 mm	0.13 mm	0.13 mm	0.4 mm	0.13 mm
51-100	0.1 mm	0.6 mm	1.5 mm	0.13 mm	0.13 mm	0.5 mm	0.13 mm
101-150	0.2 mm	0.6 mm	3.2 mm	0.4 mm	0.4 mm	0.8 mm	0.4 mm
151-170	0.2 mm	1.25 mm	3.2 mm	0.4 mm	0.4 mm	0.8 mm	0.4 mm
171-250	0.2 mm	1.25 mm	6.4 mm	0.4 mm	0.4 mm	0.8 mm	0.4 mm
251-300	0.2 mm	1.25 mm	12.5 mm	0.4 mm	0.4 mm	0.8 mm	0.8 mm
301-500	0.25 mm	2.5 mm	12.5 mm	0.8 mm	0.8 mm	1.5 mm	0.8 mm
> 500 See para. 6.3 for calc.	0.0025 mm /volt	0.005 mm /volt	0.025 mm /volt	0.00305 mm /volt	0.00305 mm /volt	0.00305 mm /volt	0.00305 mm /volt

B1 - Internal Conductors
B2 - External Conductors, uncoated, sea level to 3050 m
B3 - External Conductors, uncoated, over 3050 m
B4 - External Conductors, with permanent polymer coating (any elevation)
A5 - External Conductors, with conformal coating over assembly (any elevation)
A6 - External Component lead/termination, uncoated
A7 - External Component lead termination, with conformal coating (any elevation)

Electrical Conductor Spacing (cont.)

IPC-2221 – **6.3.2 B2-External Conductors, Uncoated, Sea Level to 3050 m** Electrical clearance requirements for uncoated external conductors are significantly greater than for conductors that will be protected from external contaminants with conformal coating. If the assembled end product is not intended to be conformally coated, the bare board conductor spacing **shall** require the spacing specified in this category for applications from sea level to an elevation of 3050 m. See Table 6-1.

IPC-2221 – **6.3.3 B3-External Conductors, Uncoated, Over 3050 m** External conductors on uncoated bare board applications over 3050 m require even greater electrical spacings than those identified in category B2. See Table 6-1.

IPC-2221 – **6.3.4 B4-External Conductors, with Permanent Polymer Coating (Any Elevation)** When the final assembled board will not be conformally coated, a permanent polymer coating over the conductors on the bare board will allow for conductor spacings less than that of the uncoated boards defined by category B2 and B3. The assembly electrical clearances of lands and leads that are not conformally coated require the electrical clearance requirements stated in category A6 (see Table 6-1). This configuration is not applicable for any application requiring protection from harsh, humid, contaminated environments.

Typical applications are computers, office equipment, and communication equipment, bare boards operating in controlled environments in which the bare boards have a permanent polymer coating on both sides. After they are assembled and soldered the boards are not conformal coated, leaving the solder joint and soldered land uncoated.

Note: All conductors, except for soldering lands, must be completely coated in order to ensure the electrical clearance requirements in this category for coated conductors.

IPC-2221 – **6.3.5 A5-External Conductors, with Conformal Coating Over Assembly (Any Elevation)** Externalconductors that are intended to be conformal coated in the final assembled configuration, for applications at any elevation, will require the electrical clearances specified in this category.

Typical applications are military products where the entire final assembly will be conformal coated. Permanent polymer coatings are not normally used, except for possible use as a solder resist. However, the compatibility of polymer coating and conformal coating must be considered, if used in combination.

IPC-2221 – **6.3.6 A6-External Component Lead/ Termination, Uncoated** External component leads and terminations, that are not conformal coated, require electrical clearances stated in this category.

Typical applications are as previously stated in category B4. The B4/A6 combination is most commonly used in commercial, non-harsh environment applications in order to obtain the benefit of high conductor density protected with permanent polymer coating (also solder resist), or where the accessibility to components for rework and repair is not required.

IPC-2221 – **6.3.7 A7-External Component Lead/ Termination, with Conformal Coating (Any Elevation)** As in exposed conductors versus coated conductors on bare board, the electrical clearances used on coated component leads and terminations are less than for uncoated leads and terminations.

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Index (cont.)

Index (cont.)

ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

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IPC-A-610C

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Acceptability of Printed Boards
Designers Certification Preparation
New Design Standards
High Speed Design
Design for Manufacturability
Design for Assembly

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APPLICABLE DOCUMENTS TO THE IPC-A-610

Standards

IPC/EIA J-STD-001C **Requirements for Soldered Electrical and Electronic Assemblies**

This is the industry standard for commercial and high-reliability assemblies. MIL-STD-2000 has been cancelled, leaving J-STD-001C as the sole industry-consensus standard for soldering. This standard describes materials, methods and verification criteria for producing quality soldered interconnections and assemblies. Co-produced with EIA.

IPC/EIA J-STD-002A **Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires**

Covers the assessment of the solderability of electronic component leads, terminations, solid wire, stranded wire, lugs and tabs. Prescribes test methods, defect definitions, acceptance criteria and illustrations for suppliers and users. Co-produced with EIA.

ANSI/J-STD-003 **Solderability Tests for Printed Boards**

Contains industry-recommended test methods, defect definitions and illustrations for suppliers and users to assess the solderability of printed board surface conductors, lands and plated-through holes. Test methods covered include edge dip, rotary dip, solder float, wave solder and wetting balance. Co-produced with EIA.

ANSI/J-STD-004 **Requirements for Soldering Fluxes** (Includes Amendment 1)

Describes general requirements for classifying and testing of rosin, resin, organic and inorganic fluxes for high quality interconnections. This standard is a flux characterization, quality control and procurement document for solder flux and flux-containing materials of all compositions, including no-clean. Supersedes QQ-S-571 and MIL-F-14256. Co-produced with EIA.

ANSI/J-STD-005 **Requirements for Soldering Pastes**

Lists general requirements for characterization and test of metal content, viscosity, slump, solder ball, tack and wetting of solder pastes. (This is a quality control document and is not intended to relate directly to a material's performance in the manufacturing process.) Supersedes QQ-S-571. Co-produced with EIA.

ANSI/J-STD-006 **Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications**

Describes requirements and test methods for electronic grade solder alloys, and for fluxed and non-fluxed bar, ribbon, and power solders other than solder paste for electronic grade solders. Supersedes QQ-S-571 and MIL-F-14256. Co-produced with EIA.

IPC-T-50F **Terms and Definitions for Interconnecting and Packaging Electronic Circuits**

This standard provides descriptions and illustrations to help users and their customers speak the same language. Also included is a section of acronyms and an index of IPC-T-50F terms by technology types.

IPC-A-600F **Acceptability of Printed Boards**

Contains full-color photographs and illustrations of preferred, acceptable and rejectable conditions for plated-through holes, surface plating, solder coating, base materials, etching, conductors, mechanical processes, flexible and multilayer boards; bow/twist, flat cable and other conditions of printed wiring boards.

IPC-CC-830A **Qualification and Performance of Electrical Insulating Compound for Printed Board Assemblies**

This is the industry standard for qualifying conformal coating. It was designed and constructed with the intent of obtaining maximum information about the confidence in the electrical insulating compound (conformal coating) material under evaluation with a minimum of test redundancy. Includes evaluation of material properties and procedures to qualify a coating using the standard test board.

IPC-SM-840C **Qualification and Performance of Permanent Solder Mask**

Streamlines solder mask classes into two classifications: H (high reliability) and T (telecommunications). IPC-SM-840C also integrates Bellcore requirements (class T) and provides minimum voltage breakdown, defines mask formulation latitude, adds new mask chemistries and more.

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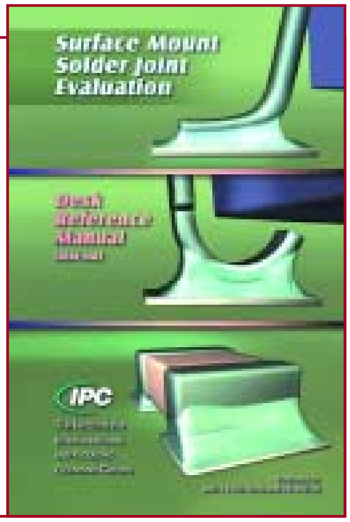
More Acceptability RESOURCES

IPC-DRM-SMT
Surface Mount Solder Joint Evaluation - Desk Reference Manual



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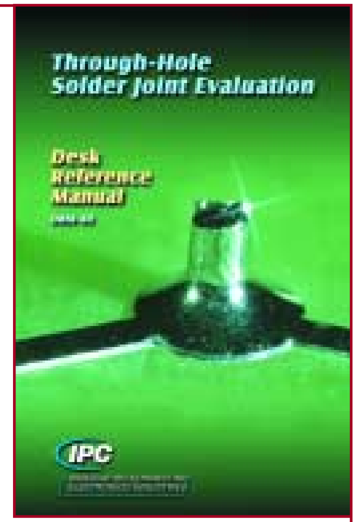

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